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JUNE, 1837.

Practical and Theoretical Mechanics.

Report of the Committee of the Franklin Institute of the State of Pennsylvania on the Explosions of Steam Boilers, of Experiments made at the request of the Treasury Department of the United States. PART II. *Containing the report of the sub-committee to whom was referred the examination of the strength of the materials employed in the construction of Steam Boilers.*

[CONTINUED FROM PAGE 361.]

Strength of iron made by other processes than rolling into plates.

The tables numbered from LIX. to LXXVIII. inclusive, will be found to contain the results of experiments on various specimens of iron manufactured by other processes than rolling into boiler-plate, particularly those of hammering into bars, slitting into rods, rolling into bolts and drawing into wires.

In the number of specimens here tried the committee have included a few of foreign iron, Russian, Swedish and English, as well with a view to compare the results of their method of trial with those of former experimenters, as to show how far the processes generally adopted in manufacturing the article in this country may admit of improvement.

A few experiments on boiler-iron, made upon original or on filed sections, will be found in Table LIX., and a small number of trials on cast iron, which does not, however, appear to have been of a very favourable character. Table LX. also contains accounts of a miscellaneous collection of specimens obtained from different quarters. The remaining tables in this series relate to bars which had been reduced to approximate uniformity of size throughout their whole length, and not a few of them were tried at elevated as well as ordinary temperatures; but of the former we shall speak more at length in a subsequent part of this report.

TABLE LIX.

Experiments on bars No. 99, 101, 103, 105, 180, 181, 182 and 185. The first two manufactured by Pennock into boiler plate; the next two by Jackson into the same article, and the remaining numbers obtained from

No. of the bar.	Direction of the slit.	No. of the exp.	DATE.	Length before trial.	Breadth.	Thickness.	Area of the section of fracture before trial.	Temp. Fah.	Breaking wht. in the scale.	Breaking wht. × leverage.	Friction.	Effective strain.	Strength in lbs. per sq. inch.
			1832.										
99	Cross.	1		24.3	1.016	.214	.217424	62.25	378	11340	567	10773	49548
101	L'gth.	2		25.1	1.014	.230	.233220	62.5	403	12090	604	11486	49258
101	"	3			.826	.240	.198240	62.5	384	11520	576	10944	55206
103	Cross.	4		23.8	1.038	.190	.197220	62.25	321	9630	481	9149	41319
103	"	5	May 30,	9.6	.984	.200	.196800	67.	361	10830	541	10289	52281
105	L'gth.	6	Ap. 28,	24.2	1.050	.196	.205800	62.5	322	9660	483	9177	44591
105	"	7			1.045	.196	.204820	62.5	345	10350	517	9833	48068
On a bar of slit iron hammered out, having two sections much smaller than the rest but equal to each													
180	Hammered and upset.	8		10.25	.882	.216	.190512	60.	324	9720	486	9234	48469
On a bar of cast steel furnished by Mr. R. Tyler in which were two equal square sections, 31 of an inch													
181	Cast steel.	9			.310	.310	.096100	65.	441	13230	661	12569	130681
On a bar of iron furnished by Mr. Super, manufactured by Washington Jackson, rolled and slit.													
182	Rolled & slit.	10		23.5	.980	.254	.248920	65.	455	13650	682	12968	52096
On a bar of cast iron obtained from the foundry of Messrs. Levi Morris & Co. Philadelphia.													
185	Cast iron.	11		24.	1.032	.280	.288960	69.	196	5880	294	5586	19337
185		12		19.2	1.054	.280	.295120	69.	210	6300	315	5985	20279
185		13			1.056	.250	.264000	69.	212	6360	318	6042	22886

TABLE LIX.

different quarters, as specified below. Specific gravities not taken.

Weights producing temporary elongation.	Elasticity of the bar.	Length after trial.	Area of the section after trial.	REMARKS.
224 336 378 378	20′ 36 42 Broke.	24.45	1.010×.204 =.206040	Broke under 378 lbs. after the elasticity had been observed. Gave way suddenly. A small scale or flaw appeared on one side of the section of fracture.
224 336 403	35 41 Broke.	25.3	.986×.210 =.207060	
			.821×.196 =.160916	Broke at the filed section.
224 280 308 321	38 34 43.5 Broke.	24.09	1.014×.174 ×.176436	
168 361	07. Broke.	9.8	.942×.152 =.143184	
224 294 320 322	1.03 1.04 1.03 Broke.	24.45*	1.024×.180 =.184320	Broke near the wedges. * The length after fracture is that of the whole bar after both trials.

ther; the one upset—the other not. Furnished by Mr. Rufus Tyler.

		10.86		Direct measurements were taken to ascertain the recoil of the bar when relieved from strain under different whts. With 224 lbs. the length was 10.40 when the weight was applied; but only 10.366 when it was taken off.—With 250 lbs. it was 10.50 and 10.45 in the two cases; and with 273 lbs. 10.62 and 10.60. Broke at the section *not upset.*

on a side, the one upset—the other not.

112 224 336 385 406 415 422 429 441	20.5 30. 28. 36.5 40.5 39.5 36.5 37.5 Broke.		.840×.190 =.159600	Broke at the *upset* part.
		25.66		
168 196	37 Broke.			A filed section was made;—its area 1.018×.230=.234140. Broke suddenly with the weight recorded—filed section not broken.
189 210	35 Broke.			Do. It was found difficult to make the wedges hold the cast bars so as to equalize the strain. The filed section remains unbroken and has of course borne 25.762 lbs. to the sq. inch.

TABLE LX.

Experiments on a variety of specimens of iron, furnished by different

No. of the bar.	Mode of manufacture.	DATE.	No. of the exp't.	Length before trial.	Breadth.	Thickness.	Area of the section of fracture before trial.	Temp. Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.
On a bar furnished by Mr. R. Tyler, in which was a section annealed at a												
191	Ham. & annealed.		1	15.	.880	.220	.193600	68	326	9780	489	9291
On a small railroad bar of English "common iron," in which a deep section had Furnished by Gerard Ralston, Esq. of Philadelphia.												
215	Rolled into rail.		2		.740	.262	.193880	81	412	12360	618	11742
On a rod of round iron made from the pig, by puddling, piling, and then rolling,												
217	Puddled, pil. & rol.		3		Diam. .660	Diam. .660	.342120	68	700	21000	1050	19950
On specimens of Juniata iron, both *hammered* and *slit*. Furnished by Mr. G.												
234	Hamm'd.	1833. May 18,	4		.357	.357	.127449	77	254	7620	381	7239
234	"	"	5		.300	.382	.114600	77	209	6270	313	5959
234	"	"	6		.368	.382	.140576	77	273	8190	409	7781
235	Rolled & slit.	"	7		.300	.295	.088500	77	196	5880	294	5586
On a small bar furnished by Messrs. Yeatman & Woods, of Nashville, Tenn.												
236	Rolled.	"	8		.324	.392	.127008	77	231	6930	346	6584
On a bar of rolled and slit iron, manufactured with coke, and reduced by pud- Susquehanna, Pa.												
244	Rolled & slit.	1836. Mar. 21.	9	4.5	.337	.253	.085261	50	209	6270	313.5	58565

TABLE LX.

individuals, as mentioned below. Specific gravity not taken.

Strength in lbs. per square inch.	Length after trial.	Area of section after trial.	REMARKS.
welding heat.			
47991	16.42	.766×.156 =.119496	Broke at the annealed part. Began to be permanently elongated with 210 lbs. and continued to extend with the successive additions of weight until broken.
been filed, the bar being originally an inch wide and one-third of an inch thick.			
60563			This section was so deeply filed as to remove all probability of a defect in the *remaining* section.
without any other operation for refining the metal. Furnished by **Jonah Thompson, Esq.**			
58313			
Valentine, of Centre county, Pennsylvania.			
56799			
51981			
55351			
63119			
51839			
dling. Furnished by Peter Ritner, Esq., Carthause's place, West Branch of the			
68689			Fracture granular, with much crystalline structure. A yellowish tinge perceptible in certain parts.

TABLE LXI

Experiments on bars No. 212 *and* 213, *drawn out of a specimen of English bolt iron* $1\frac{1}{8}$ *inches in diameter, presented by G. Ralston, Esq., described as, "E. V. best patent cable bolt iron." The specimen had been formed into a knot when cold, by means of a pair of pincers. The*

Marks. Bar 213.	Breadth.	Thickness.	Area of the sections measured before trial.	No. of the experiment.	DATE.	Area at the section of fracture.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.	Strength in pounds per square inch.
1	.741	.239	.177099		1833.							
2	.743	.236	.175348	1	July 20,	.175171	560°	364	10920	546	10374	59222
3	.743	.236	.175348									
4	.743	.236	.175348	2	"	.175348	80	366	10980	549	10431	59487
5	.742	.236	.175112									
6	.743	.236	.175348	3	July 25,	.175348	84	410	12300	615	11685	66639
7	.743	.235	.174605									
8	.744	.235	.174840	4	"	.174976	80	436	13080	654	12426	71015
9	.742	.236	.175112									
10	.744	.236	.175584	5	"	.174859	78	439	13170	658	12512	71555
11	.744	.236	.175584									
12	.744	.236	.175584	6	"	.175128	78	437	13110	655	12455	71119
13	.744	.239	.177816									
14	.741	.238	.176358	7	"	.173628	78	437	13110	655	12455	71734
15	.742	.237	.175854									
16	.741	.237	.175617	8	"	.177162	78	437	13110	655	12455	70303
17	.743	.238	.176834									
18	.740	.236	.174640	9	"	.175617	78.5	437	13110	655	12455	70921
19	.740	.236	.174640									
20	.744	.239	.177816	10	"	.175434	78.	435	13050	652	12398	70670
21	.742	.237	.175854									
22	.742	.234	.173628	11	"	.175795	77.5	436	13080	654	12426	70685
23	.742	.235	.174370									
24	.743	.236	.175348	12	"	.176358	78.	439	13170	658	12512	70947
25	.740	.236	.174640									
26	.741	.237	.175617	13	"	.175584	78.	439	13170	658	12512	71265
27	.741	.236	.174876									
					Mn. of 13 =	.175416						
Mean of 27=			.175512		Experiment on No. 212, part of the same bolt.							
					Br. Th.							
Maximum			.177816		1.041 | .256	.268496	82	565	16950	847	16103	59975
Minimum			.173628									
Mean of the 2			.175722									
Diff. of the 2			.004188									

TABLE LXI.

exterior dimensions of the knot were 5⅛ by 3⅛ inches. After heating and untieing this knot the bar was drawn out by the hammer. No. 213 was reduced to a nearly uniform size by filing, and then gauged at every inch, from 1 to 27 inches. No. 212 tried at a filed section. Sp. grav. 7.6897.

Point of fracture.	REMARKS.
No. 4½	Part in tin from 5 to 8. The influence of the heat at this temperature was made to extend to all parts of the bar—with a view to ascertain whether any points of inferior strength could be thereby detected—but the structure appears to have been remarkably uniform, as seen in subsequent trials.
" 3	
" 9½	
" 6½	
" 23½	
" 25½	
" 22	
" 20⅓	
" 16	
" 19¼	
" 15½	
" 14	
" 12	
	The mean area of the 13 sections of fracture is .000096 square inch *less* than the mean area of the 27 measured sections.
	This fracture made on a filed section.

TABLE LXII.

Experiments on bar No. **214**, *drawn out of a specimen (the same with* **213**) *of English cable bolt iron,* $1\frac{1}{8}$ *inches in diameter, presented by G. Ralston, Esq., described as "E. V. best patent cable bolt iron." The*

Marks.	Breadth.	Thickness.	Area of section at the points measured.	DATE.	No. of the experiment.	Area of the section of fracture before trial.	Temperature. Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.	Strength in lbs. per square inch.
1	.752	.239	.179728	1833.								
2	.751	.237	.177987	July 27,	1	.177750	83°	354	10620	531	10089	56759
3	.750	.237	.177750									
4	.750	.237	.177750									
5	.750	.239	.179250	"	2	.178066	83	370	11100	555	10545	59219
6	.750	.239	.179250									
7	.750	.239	.179250									
8	.749	.239	.179011									
9	.750	.241	.180750									
10	.749	.341	.180509									
11	.749	.241	.180509	"	3	.180509	824 / 814	354	10620	531	10089	55892
12	.749	.241	.180509									
13	.749	.239	.179011									
14	.747	.238	.177786									
15	.752	.239	.179728	"	4	.179250	81	408	12240	612	11628	64870
16	.751	.240	.180240									
17	.750	.239	.179250	"	5	.180690	82	434	13020	651	12369	68454
18	.749	.239	.179011									
19	.748	.240	.179520									
20	.750	.239	.179250	"	6	.179130	932	283	8490	424	8066	45029
21	.750	.240	.180000									
22	.748	.241	.180268									
23	.749	.240	.179760									
24	.749	.240	.179760									
25	.752	.240	.180480	"	7	.179760	1022	236	7080	354	6726	37410
26	.752	.241	.181232									
27	.752	.238	.178976									
Mean of 27			.179501	Aug. 1,	8	.179760	80	294	8820	441	8379	46612
Maximum			.181232	"	9	.180141	80	383	11490	574	10916	60597
Minimum			.177750	"	10	.179393	80	383	11490	574	10916	60850
				"	11	.180240	80	362	10860	543	10317	57240
Mn. of these 2			.179491	"	12	.180856	80	380	11400	570	10830	59882
				"	13	.179745	80	377	11310	565	10745	59779
Diff. of the 2			.003482	"	14	.180069	80	392	11760	588	11172	62043
				"	15	.178092	80	401	12030	601	11429	64175
				Mean of 15		.179563						

TABLE LXII.

bar reduced by hammering and filing to uniform size, and then gauged at every inch from 1 *to* 27. *Specific gravity*, 7.6897.

Breadth after trial.	Thickness after trial.	Area after trial.	Point of fracture.	REMARKS.
			No. $3\frac{3}{4}$	
			" $2\frac{1}{2}$	Short piece broken off in the preceding experiment. These two experiments were made on the bar when *cold*, with a view to get the approximate tenacity in that state.
.623	.196	.122108	" $10\frac{1}{2}$	Having placed in the scale the same weight as was used in the first experiment, the temperature was raised, by means of the moveable furnace, to such a point that the bar was rapidly giving way. The standard piece was withdrawn and tried twice, giving, successively, the temperatures marked.
			" $6\frac{1}{4}$	Part now in the machine from $3\frac{3}{4}$ to $10\frac{1}{2}$
			" $9\frac{1}{4}$	Same part under trial as in the preceding exp't.
.563	.174	.099651	" $17\frac{1}{2}$	The scale was now loaded with four-fifths of the breaking weight in the first experiment. The difference of areas caused an excess of 452 lbs. above four-fifths of the strength exhibited in that experiment. Bar not actually parted.
.603	.185	.111555	" $23\frac{3}{4}$	Part in tin from 22 to 25. The weight employed $\frac{4}{5}$ of that used in the first experiment. Section larger, hence the strength is 978 lbs. less than $\frac{4}{5}$ of 56759. The length from 23 to 24 was now 1.46 in. Not actually parted.
			" $23\frac{3}{4}$	The same section as that tried in the preceding experiment.
			" $22\frac{1}{4}$	
			" $18\frac{3}{4}$	
			" $24\frac{3}{4}$	
			" $25\frac{1}{2}$	
			" $16\frac{1}{2}$	
			" $15\frac{3}{4}$	
			" $13\frac{3}{4}$	
				The mean area of 15 sections of fracture is .000062 square inch *greater* than the mean area of the 27 measured sections.

TABLE LXIII.

Experiments on bars No. 213*a* *and* 214*a, taken respectively from bars* 213 *and* 214. *Reduced by hammering and filing to a nearly uniform*

Marks.	Breadth.	Thickness.	Area before trial at the points measured.	No. of the experiment.	DATE.	Area of the section of fracture before trial.	Temperature Fahrenheit.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.
		213*a*									
1	.748	.230	.172040								
2	.746	.230	.171580	1		.171580	78	396	11880	594	11286
3	.747	.232	.173304								
4	.747	.229	.171063								
5	.747	.229	.171063	2		.170949	78	421	12630	631	11999
6	.745	.229	.170605								
7	.745	.230	.171350								
8	.745	.230	.171350	3		.170605	78	431	12930	646	12284
9	.745	.230	.171350								
Mean of 9			.171534	4		.170977	78	431	12930	646	12284
Maximum			.173304		Mn. of 4 =	.171028					
Minimum			.170605								
Mn. of the 2			.171954								
Diff. of the 2			.002699								
		214*a*									
1	.750	.226	.169500								
2	.747	.225	.168075	1		.169231	80	410	12300	615	11685
3	.743	.225	.167175								
4	.743	.228	.169404								
5	.744	.228	.169632	2		.169518	80	412	12360	618	11742
6	.739	.226	.167014								
7	.739	.227	.167753								
8	.739	.227	.167753	3		.168246	84	443	13290	664	12626
9	.739	.229	.169231								
10	.739	.228	.168492								
				4		.168966	84	438	13140	657	12483
Mean of 10			.168402								
					Mn. of 4 =	.168990					
Maximum			.169632								
Minimum			.167014								
Mn. of these 2			.168323								
Diff. of the 2			.002618								

TABLE LXIII.

size, and then gauged at every inch. These bars were both hammered until cold, technically "hammer-hardened."

Strength in lbs. per sq. inch.	Point of fracture.	REMARKS.
65718	No. 2	
70190	" 5¼	
72002	" 6	
71845	" 6½	The mean area of these 4 sections of fracture is .000506 square inch *less* than the mean area of the 9 measured sections.
69047	" 9	
69267	" 4½	
75045	" 8½	
73879	" 1⅞	The mean area of these 4 sections of fracture is .000498 square inch *greater* than the mean area of the 10 measured sections.

TABLE LXIV.

Experiments on a specimen of iron wire. Manufactured at Phil- process of manufacture, refining, &c. not stated.

No. of the bar.	Mode of manufacture.	DATE.	Number of the experiment.	Diameter before trial.	Area of section before trial.	Temperature. Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.
199	Wiredrawn.		1	.333	.0870922	550°	246	7380	369
199	"		2	.333	"	66	253	7590	379
199	"		3	.333	"	66	257	7710	385
199	"		4	.333	"	66	257	7710	385
199	"		5	.333	"	66	257	7710	385
199	"		6	.333	"	60	258	7740	387
199	"		7	.333	"	50	270	8100	405
199	"		3	.333	"	50	221	6630	331
199	"		9	.333	"	60	236	7080	354
199	"		10	.333	"	450	242	7260	363
199	"		11	.333	"	60	249	7470	373
199	"		12	.333	"	60	241	7230	361
199	"		13	.333	"	60	243	7290	364

TABLE LXIV.

lipsburg, Pennsylvania, by Mr. Hardman Phillips, from Juniata iron,

Effective strain.	Strength in lbs. per square inch.	Area of section after trial.	REMARKS.
			The specific gravity of this wire was 7.7272.
7011	80501		
7211	82797	$\left\{\begin{matrix}.240\times.240\times.7854\\ =.045239\end{matrix}\right\}$	Only two measurements of area after fracture are recorded, but others were occasionally taken, all agreeing very nearly with these, and exhibiting a uniform diminution in all directions, and a remaining section almost precisely one-half as great as the original transverse section of the wire.
7325	84106		
7325	84106		
7325	84106		
7353	84427		
7695	88354		
6299	72325		
6726	77228		
6897	79192		
7097	81488		
6869	78870	$\left\{\begin{matrix}.234\times.234\times.7854\\ =.0430132\end{matrix}\right\}$	
6926	79524		

TABLE LXV.

Experiments on bar No. 223 A. From Missouri. Manufactured by Mr. Massey, at the Maramec Iron Works. Drawn under the hammer

Marks.	Breadth.	Thickness.	Area of sections measured before trial.	No. of the experiment.	DATE.	Area of section at the point of fracture before trial.	Temp. Fah.	Breaking wht. in the scale.	Breaking weight × leverage.	Friction.	Effective strain.	Strength in lbs. per sq. inch.
0	.761	.230	.175030		1833.							
1	.758	.230	.174340	1	May 2,	.175180	80	269	8070	403	7667	43766
2	.758	.232	.175856									
3	.758	.230	.174340	2	"	.174685	80	281	8430	421	8009	45896
4	.758	.230	.174340									
5	.756	.230	.173880	3	"	.174867	79.5	281	8430	421	8009	45556
6	.757	.231	.174862									
7	.758	.231	.175098	4	"	.175972	79.5	281	8430	421	8009	45513
8	.756	.232	.175392									
9	.759	.232	.176088	5	"	.175098	79.5	294	8820	441	8379	47853
10	.758	.232	.175856		1834.							
11	.759	.232	.176088	6	May 4,	.175307	570	309	9270	463	8807	50238
12	.760	.232	.176320									
13	.760	.231	.175560									
14	.760	.230	.174800	7	"	.174845	578	328	9840	492	9348	53465
15	.760	.232	.176320									
16	.759	.231	.175329									
17	.759	.229	.173811	8	"	.174665	65	363	10890	544	10346	59233
18	.759	.230	.174570									
19	.758	.232	.175856									
20	.758	.230	.174340	9	"	.173250	65	354	10620	531	10089	58239
21	.758	.231	.175098									
22	.758	.232	.175856									
23	.758	.232	.175856	10	"	.175856	65	358	10740	537	10203	58018
24	.758	.232	.175856									
25	.756	.232	.175392	11	"	.175477	65	358	10740	537	10203	58144
26	.755	.231	.174405									
26½	.750	.231	.173250		Mn. of 14 =	.175018						
Mean of 28			.175135									
Maximum			.176320									
Minimum			.173250									
Mean of the 2			.174785									
Diff. of the 2			.003070									

TABLE LXV.

and then reduced by filing and gauged at points 1 *inch apart. Specific gravity* 7.7708.

Weight producing elongation.	Increase of length in 24 inches.	Point fractured.	REMARKS.
168 224 252 269	1st permanent. . 3 inch. . 7 do. Broke.	No. $13\frac{1}{2}$	
		" $0\frac{1}{2}$	
		" 6	Weights not altered.
		" $9\frac{1}{2}$	Do.
		" $2\frac{1}{2}$	
		" $14\frac{1}{4}$	Part in tin from 18 to 22.
		" $19\frac{3}{4}$	Broke in the melted tin—part in the metal, same as in the preceding experiment.
		" $18\frac{3}{4}$	
		" $26\frac{3}{16}$	A different piece from the preceding—had been most remote from the melted metal, fracture diagonal.
		" $23\frac{3}{4}$	Had not been in tin.
		" $21\frac{1}{2}$	A flaw about the middle of the thickness now appeared.—This bar exhibited more than any yet tried, a dull recoil only, when it finally gave way, as if the elasticity had been almost totally destroyed. The mean area of the 11 sections of fracture is .000117 square inch *less* than that of the 28 measured sections.

TABLE LXVI.

Experiments on bar No. 223 B. From Missouri. Manufactured by Mr. Massey, at the Maramec Iron Works, drawn under the hammer,

Marks.	Breadth.	Thickness.	Area of section at the points measured before trial.	DATE.	No. of the exp't.	Area of the section of fracture before trial.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.
1	.764	.239	.182596								
2	.755	.240	.181200								
3	.755	.240	.181200								
4	.755	.239	.180445	1833.							
5	.755	.238	.179690	May 9,	1	.179690	76	262	7860	393	7467
6	.755	.239	.180445								
7	.755	.238	.179690								
8	.755	.236	.178180								
9	.752	.236	.177472								
10	.753	.236	.177708								
11	.753	.238	.179214	"	2	.181041	76	270	8100	405	7695
12	.755	.239	.180445								
13	.755	.238	.179690	"	3	.179172	76	271	8130	406	7724
14	.755	.239	.180445								
15	.755	.239	.180445	"	4	.180960	76	277	8310	415	7895
16	.755	.240	.181200								
17	.755	.239	.180445	"	5	.181200	76	284	8520	426	8094
18	.755	.240	.181200								
19	.756	.238	.179928	"	6	.180445	76	284	8520	426	8094
20	.756	.237	.179172	1833.							
21	.756	.239	.180684	May 11,	7	.178180	576	313	9390	469	8921
22	.755	.240	.181200								
23	.755	.240	.181200	"	8	.180445	70.5	336	10080	504	9576
24	.753	.240	.180720								
25	.755	.240	.181200	"	9	.182596	70.5	322	9660	483	9177
26	.755	.240	.181200								
27	.760	.240	.182400	"	10	.180067	70.5	347	10410	520	9890
27½	.762	.240	.182880								
				"	11	.179690	70.5	347	10410	520	9890
Mean of 28 =			.180439								
				Mean of 11		.180317					
Maximum =			.182880								
Minimum =			.177472								
Mn. of these 2			.180176								
Diff. of the 2			.005408								

TABLE LXVI.

reduced by filing, and gauged at points one inch apart. Specific gravity, 7.6742.

Strength in lbs. per square inch.	Point fractured.	REMARKS.
41555	No. 13	Under a weight of 245 lbs. in the scale the elongation had become .85 inch in 22 inches. The breadth at No. 13 was then .718, diminution .037. After this experiment 12 inches on one side of the fracture, as originally measured, were found to have been elongated to 13½, and 10 on the other to 11 1–20, exhibiting an extension of 2.55 in 22 inches.
42504	" 18⅛	
43109	" 20	
43628	" 23½	
44669	" 25½	
44855	" 14⅜	
50068	" 8	Part in tin from 6½ to 10.
53069	" 12	Part now under trial from 8 to 13.
50258	" 1	Broke soon after applying the weight. Part now under trial from 1 to 8.
54924	" 6½	Broke quickly with this weight.
55039	" 5	
		The mean area of the 11 sections of fracture is .000122 sq. inch *less* than the mean area of the 28 measured sections.

TABLE LXVII.

Experiments on bar No. 223 C. Manufactured at the Maramec Iron Works, Missouri, by Mr. Massey, drawn under the hammer, re-

Marks.	Breadth.	Thickness.	Area before trial.	No. of the exp't.	DATE.	Area of section of fracture before trial.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.
1	.741	.243	.180063		1833.		°				
3	.751	.242	.181743	1	May 11,	.180870	576	282	8460	423	8037
2	.748	.242	.181016								
4	.751	.242	.181742	2	"	.181232	578	308	9240	462	8778
5	.751	.242	.181742								
6	.751	.240	.180240	3	"	.182178	578	329	9870	493	9377
7	.751	.241	.180991								
3	.751	.242	.181742	4	May 16,	.181742	550	338	10140	507	9633
9	.751	.240	.180240								
10	.751	.240	.180240	5	"	.180870	550	331	9930	496	9434
11	.751	.242	.181742								
12	.751	.242	.181742	6	"	.179545	78	364	10920	546	10374
13	.751	.242	.181742								
14	.751	.242	.181742	7	"	.179301	78	365	10950	547	10403
15	.751	.242	.181742								
16	.751	.243	.182493	8	"	.178738	78	371	11130	556	10574
17	.752	.241	.181232								
18	.752	.241	.181232	9	"	.180991	78	372	11160	558	10602
19	.751	.241	.180991								
20	.749	.241	.180509	10	May 18,	.181742	78	369	11070	553	10517
21	.752	.241	.181232								
22	.751	.239	.179489	11	"	.181379	78	369	11070	553	10517
23	.751	.238	.178738								
24	.750	.242	.181500	12	"	.181492	78	369	11070	553	10517
25	.751	.241	.180991								
26	.751	.241	.180991	13	"	.181742	78	371	11130	556	10574
27	.748	.242	.181016								
27.25	.745	.241	.179545	14	"	.181742	78	371	11130	556	10574
	Mean of 28		.181015		Mean of 14	.180968					
	Maximum		.182493								
	Minimum		.178738								
	Mean of the 2		.180615								
	Differ. of the 2		.003755								

TABLE LXVII.

{*duced by filing, and gauged at every inch. Specific gravity* 7.7708.

Strength in lbs. per square inch.	Point of fracture.	REMARKS.
44435	No. 20½	The whole length of the bar was put under trial. The part in tin from 5½ to 9.
48435	" 18	Same part in tin as above.
51713	" 16¼	Same part in tin. This fracture is at the largest section in the bar.
53004	" 2	The same part still in tin.
52158	" 21½	Part in tin from 22 to 26. Broke at a place previously in the gripe of the wedges.
57779	" $27\frac{2}{10}$	
58020	" 22¼	
59159	" 23	
58577	" 25¼	
57879	" 13¼	
57983	" 2½	
57947	" 7⅔	
58181	" 11	
58181	" 4	
		The mean area of the 14 sections of fracture is .000047 square inch *less* than that of the 28 measured sections.

TABLE LXVIII.

Experiments on bar No. 223 D. From Missouri. Manufactured by Mr. Massey, at the Maramec Iron Works, drawn under the hammer

Marks.	Breadth	Thickness.	Areas at the points gauged.	No. of the experiment.	DATE.	Area at the point of fracture.	Temperature Fahrenheit.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.
1	.755	.242	.182710								
2	.754	.241	.181714		1833.						
3	.753	.242	.182226	1	May 30,	.182226	72°	275	8250	412	7838
4	.752	.242	.181984								
5	.752	.242	.181984								
6	.752	.242	.181984	2	"	.183407	68	357	10710	535	10175
7	.752	.242	.181984								
8	.752	.242	.181984								
9	.752	.242	.181984	3	"	.182602	68	368	11040	552	10488
10	.752	.242	.181984								
11	.753	.241	.181473								
12	.753	.242	.182226	4	"	.182736	68	368	11040	552	10488
13	.753	.242	.182226								
14	.753	.242	.182226								
15	.753	.242	.182226	5	"	.182226	528	347	10410	520	9890
16	.753	.242	.182226								
17	.753	.241	.181473								
18	.753	.242	.182226	6	"	.181849	69.5	336	10080	504	9576
19	.753	.242	.182226								
20	.753	.242	.182226								
21	.753	.243	.182976	7	June 1,	.181984	73.	375	11250	562	10688
22	.753	.243	.182979								
23	.752	.243	.182736								
24	.752	.244	.183488	8	"	.182226	73.	376	11280	564	10716
25	.752	.245	.184240								
26	.751	.244	.183244								
27	.752	.244	.183488	9	"	.181749	73.25	380	11400	570	10830
Mean of 27			.182387								
				10	"	.182710	73.5	348	10440	522	9918
Maximum			.184240								
Minimum			.181473								
				11	"	.181984	73.5	357	10710	535	10175
Mn. of the 2			.182856								
Diff. of the 2			.002767		Mean of 11	.182236					

TABLE LXVIII.

and reduced by filing. Gauged at points from 1 *to* 27 *inches. Specific gravity* 7.7708.

Strength in pounds per square inch.	Point of fracture.	REMARKS.
43012	No. 19	The whole bar in the machine.
55477	" 26⅔	Part now in from 19 to 27.
57436	" 20½	
57394	" 23	
54273	" 14¾	Part now in the machine from 4 to 19—in tin from 9½ to 13.
52657	" 16½	
58730	" 9¼	
58807	" 14½	Broke within the wedges.
59593	" 11⅓	Broke at a part which had been heated.
54283	" 1	Piece now in has not been tried before.
55911	" 4	The mean area of the 11 sections of fracture is .000151 square inch *less* than that of the 27 measured sections.

TABLE LXIX.

Experiments on bar No. 223 E. From Missouri. Manufactured by Mr. Massey, at the Maramec Iron Works. Drawn under the ham-

Marks.	Breadth.	Thickness.	Areas of section at the points measured before trial.	No. of the experim't.	DATE.	Area of the section of fracture before trial.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.
1	.742	.242	.179564								
2	.741	.240	.177840								
3	.742	.236	.175112		1833.						
4	.740	.238	.176120	1	June 6,	.178055	550° / 71	280	8400	420	7980
5	.742	.237	.175854								
6	.740	.240	.177600								
7	.740	.240	.177600								
8	.740	.241	.178340	2	"	.176001	71	298	8940	447	8493
9	.741	.241	.178581								
10	.741	.241	.178581	3	"	.176365	71	301	9030	451	8579
11	.740	.239	.176860								
12	.741	.240	.177840	4	"	.177186	71	301	9030	451	8579
13	.741	.239	.177099								
14	.741	.239	.177099	5	"	.177915	71	310	9300	465	8835
15	.741	.239	.177099								
16	.741	.239	.177099	6	"	.177170	71	310	9300	465	8835
17	.740	.238	.176120								
18	.740	.240	.177600	7	"	.178270	71	305	9150	457	8693
19	.740	.240	.177600								
20	.740	.239	.176860	8	June 13,	.177099	71	312	9360	468	8892
21	.740	.238	.176120								
22	.740	.239	.176860	9	"	.178007	71	312	9360	468	8892
23	.740	.240	.177600								
24	.741	.238	.176358	10	"	.178370	71	320	9600	480	9120
25	.741	.238	.176358								
26	.738	.238	.175644	11	"	.177600	71	320	9600	480	9120
27	.738	.239	.176382								
27.3	.745	.239	.178055	12	"	.175616	71	320	9600	480	9120
		Mean of 28	.177137		Mean of 12	.177304					
		Maximum	.179564								
		Minimum	.175112								
		Mean of these 2	.177338								
		Diff. of the 2	.004452								

TABLE LXIX.

mer, reduced by filing, and gauged at points one inch apart. Specific gravity, 7.6742.

Strength in lbs. per square inch.	Point of fracture.	REMARKS.
44818	No. 27 3/10	Put into tin from 22 to 25½. After a strain of 273 lbs. the packing gave way. The temperature of the tin at this time being 550°. After this the bar was broken up at 71°. Broke near the wedges—had not been in tin.
48255	" 25½	Had barely touched the tin.
48592	" 16¾	
48418	" 23½	Shorter piece now in from 16¾ to 25½.
49799	" 19¼	
49811	" 22½	
48763	" 1¾	Longer piece now under trial from 1 to 16¾.
50209	" 13½	
49953	" 10½	
51129	" 8⅞	
51351	" 6½	
51931	" 3½	

The mean area of the 12 sections of fracture was .000167 square inch *greater* than that of the 28 measured sections.

TABLE LXX.

Experiments on bar No. 224 A. Manufactured by Messrs. Yeatman & Woods of Nashville, Tennessee. Drawn under the ham-

Marks.	Breadth.	Thickness.	Area before trial.	No. of the experiment.	DATE.	Area of the section of fracture.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.
1	.753	.233	.175449		1833.						
2	.754	.233	.175682	1	May 23.	.176202	82	311	9330	466	8864
3	.755	.233	.175915								
4	.753	.233	.175449								
5	.754	.234	.176436	2	"	.175536	82	327	9810	490	9320
6	.754	.232	.174928								
7	.753	.233	.175449								
8	.753	.234	.176202	3	"	.175799	82	327	9810	490	9320
9	.753	.233	.175449								
10	.752	.234	.175968								
11	.753	.234	.176202	4	"	.174928	82	327	9810	490	9320
12	.748	.233	.174284								
13	.753	.232	.174696								
14	.754	.230	.173420	5	"	.174703	82	322	9660	483	9177
15	.754	.232	.174928								
16	.753	.233	.175449								
17	.753	.232	.174696	6	"	.175245	578	364	10920	546	10374
18	.755	.233	.175915								
19	.753	.233	.175449								
20	.752	.233	.175216	7	May 25.	.175216	76	379	11370	568	10802
21	.754	.234	.176436								
22	.754	.235	.177190								
23	.753	.234	.176202	8	"	.176907	76	386	11580	579	11001
24	.753	.234	.176202								
25	.755	.235	.177425								
26	.752	.233	.175216	9	"	.176202	76	400	12000	600	11400
27	.755	.231	.174405								
Mean of 27			.175422	10	"	.175565	76	386	11580	579	11001
Maximum			.177425								
Minimum			.173420	11	"	.175188	76	394	11820	591	11229
Mean of the 2			.175422		Mean of 11	.175772					
Diff. of the 2			.004005								

TABLE LXX.

mer, subsequently reduced by filing, and gauged at every inch. Specific gravity 7.8319.

Strength in pounds per square inch.	Point of fracture.	REMARKS.
50306	No. 8	
53095	" $1\frac{5}{8}$	
53020	" $3\frac{1}{4}$	
53279	" 6	
52511	" $11\frac{3}{4}$	
59197	" $19\frac{7}{8}$	Broke in tin.—Part included in the machine from $17\frac{1}{2}$ to 22.
61649	" 26	
62185	" $21\frac{5}{8}$	
61699	" 24	
62660	" $18\frac{3}{4}$	
64668	" $15\frac{1}{2}$	The mean area of the 11 sections of fracture is .000350 square inch *greater* than that of the 27 measured sections.

TABLE LXXI.

Experiments on bar No. 224 B. Manufactured by Messrs. Yeatman & Woods, at Nashville, Tennessee. Drawn with the hammer,

Marks.	Breadth.	Thickness.	Area before trial.	No. of the experiment.	DATE.	Area of the section at the point of fracture.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.	Strength in pounds per square inch.	Breadth after fracture.
0	.765	.236	.180540		1833.								
1	.759	.237	.179883	1	June 27.	.178947	574°	322	9660	483	9177	51283	
2	.759	.236	.179124										
3	.759	.241	.182919	2	"	.179693	564	329	9870	493	9377	52183	
4	.758	.236	.178888										
5	.758	.237	.179646	3	"	.179646	578	350	10500	525	9975	55526	
6	.758	.237	.179646										
7	.760	.236	.179360	4	"	.179646	578	356	10680	534	10146	56478	
8	.760	.236	.179360										
9	.758	.236	.178888	5	"	.179431	520	368	11040	552	10488	58451	
10	.758	.237	.179646										
11	.758	.236	.178888	6	"	.179646	100	390	11700	585	11115	61872	
12	.758	.237	.179646				app.						
13	.758	.237	.179646	7	"	.180376	100	390	11700	585	11115	61621	
14	.758	.237	.179646				app.						
15	.759	.237	.179883	8	"	.179267	75	398	11940	597	11343	63275	
16	.759	.236	.179124										
17	.754	.237	.178698	9	"	.179503	75	405	12150	607	11543	64305	
18	.758	.236	.178888										
19	.756	.236	.178416										
20	.758	.237	.179646	10	"	.179457	75	390	11700	585	11115	61937	
21	.753	.237	.178461										
22	.755	.238	.179690										
23	.757	.238	.180166				1100						
24	.758	.237	.179646	11	June 29.	.179492	to	168	5040	252	4788	26675	.500
25	.758	.236	.178888				1200						
26	.759	.236	.179124										
Mean of 27			.179494										
				12	"	.179314	75	355	10650	532	10118	56425	
Maximum=			.182919										
Minimum=			.178888	13	"	.179053	75	348	10440	522	9918	55391	
Mean of the 2			.180903	14	"	.179457	75	359	10770	538	10232	57016	
Diff. of the 2			.004031		Mn. of 14=	.179494							

TABLE LXXI.

reduced by filing to a nearly uniform size, and gauged at every inch
Specific gravity 7.8046.

Thickness after frac.	Area after fracture.	Area *after*, in parts of that *before* fracture.	Point of fracture.	REMARKS.
			No. 25¼	Part in tin from 4 to 8.
			" 15¼	Do.
			" 13¾	Do.
			" 12	Do.
			" 6¾	Broke in tin.—Temperature had been at 590°.
			" 5¾	
			" 0¼	
			" 4½	
			" 1½	
			" 9¾	This is a different piece from the preceding—part on the opposite side of the hot fracture.
.130	.065000	.362	" 19⅞	Put on 336 lbs. which it bore without signs of yielding—took off one half the weight and then applied a lamp directly below the bar to raise the temperature until it should give way, which it did at a red heat, barely visible in daylight.
			" 15¾	Broke at a part most remote from the portion just heated.
			" 20½	
			" 24¼	The mean area of the 14 sections of fracture is *identical* with that of the 27 measured sections.

TABLE LXXII.

Experiments on bar No. 224 C. Manufactured by Messrs. Yeatman & Woods, at Nashville, Tennessee. Drawn under the hammer,

Marks.	Breadth.	Thickness.	Area of section at the points measured.	Number of the experiment.	DATE.	Area of the section at the point of fracture.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.
					1833.					
0	.760	.238	.180880	1	June 29.	.183828	580°	311	9330	466
1	.757	.242	.183194							
2	.756	.241	.182196							
3	.756	.239	.180684	2	"	.182400	590	311	9330	466
4	.756	.241	.182196							
5	.757	.242	.183194							
6	.757	.241	.182437	3	"	.184265	562	378	11340	567
7	.757	.242	.183194							
8	.757	.242	.183194							
9	.760	.241	.183160	4	"	.183171	80	401	12030	601
10	.759	.242	.183678							
11	.761	.243	.184923							
12	.759	.243	.184437	5	"	.182945	80	401	12030	601
13	.760	.242	.183920							
14	.760	.239	.181640							
15	.760	.241	.183160	6	July 6,	.183748	80	351	10530	526
16	.761	.242	.184162							
17	.761	.242	.184162							
18	.761	.243	.184923	7	"	.183160	80	369	11070	553
19	.760	.241	.183160							
20	.760	.241	.183160							
21	.760	.240	.182400	8	"	.182626	77	231	6930	346
22	.761	.241	.183401							
23	.759	.242	.183678							
24	.761	.241	.183401	9	"	.183470	77	249	7470	373
25	.760	.240	.182400							
26	.763	.241	.183883	10	"	.183141	77	253	7590	379
		Mean of 27	.183141	11	"	.182650	77	256	7680	384
		Maximum	.184923	12	"	.182445	77	237	7110	355
		Minimum	.180684							
				13	"	.182529	77	249	7470	373
		Mean of these 2	.182803							
		Diff. of the 2	.004341	14	"	.181169	77	255	7650	382
						Mean of 14	.183110			

TABLE LXXII.

reduced by filing to a nearly uniform size, and gauged at every inch. Specific gravity, 7.7781.

Effective strain.	Strength in lbs. per square inch.	Point fractured.	REMARKS.
8864	48219	No. 15⅔	Part in tin from 3 to 6½.
8864	48596	" 14½	
10773	58465	" 12⅓	Being less than 6 inches from the tin, the place of this fracture was probably heated to 150 or 200° at the time. Calculating for this weight (378 lbs.) on the smallest section now in the tin, it gives 59623 lbs. per square inch.
11429	62395	" 8⅔	
11429	62472	" 4¼	After this fracture the section was found to be in breadth, .572; thickness, .159; area .090948; showing the present area to be less than half the original section, for .090948×2=.181896.
10004	54226	" 18⅔	The piece now under trial had been previously tried with only 311 lbs. in the scale, having been broken off at the first experiment.
10517	57420	" 20	The same piece as in the preceding trial.
6584	36052	" 5¾	Short piece.—*Had been in tin.*—Area at the time of this trial .150664. Calculating on this area, we obtain a strength of 43700 lbs. per square inch. This and the following experiments were on annealed sections.
7097	38682	" 23¾	Had not been in tin.
7211	39374	" 25½	Do.
7296	39945	" 21¼	Do.
6755	37025	" 4½	Had been in tin.
7097	38887	" 1⅔	
7268	40118	" 0⅛	

The mean area of the 14 sections of fracture is .000031 square inch *less* than that of the 27 measured sections.

TABLE LXXIII.

Experiments on bar No. 224 D. Manufactured by Messrs. Yeatman & Woods, at Nashville, Tennessee. Drawn by the hammer,

Marks.	Breadth.	Thickness.	Area of section before trial.	No. of the experiment.	DATE.	Area of the section of fracture before trial.	Temp. Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.	Strength in pounds per square inch.	Breadth after fracture.
0	.768	.237	.182016										
1	.755	.237	.178935		1833.								
2	.756	.239	.180684	1	July 13,	.184558	570°	314	9420	471	8949	48489	.518
3	.757	.239	.180923										
4	.759	.241	.182919										
5	.760	.243	.184680										
6	.760	.240	.182400	2	"	.186010	550	314	9420	471	8949	48110	
7	.760	.242	.183920										
8	.759	.242	.183678	3	"	.183920	560	322	9660	483	9177	49891	
9	.758	.242	.183436										
10	.758	.242	.183436	4	"	.184110	540	340	10200	510	9690	52631	
11	.758	.242	.183436										
12	.760	.242	.183920										
13	.760	.243	.184680										
14	.760	.242	.183920	5	"	.178935	440	372	11160	558	10602	59262	
15	.760	.242	.183920										
16	.760	.245	.186200										
17	.760	.245	.186200	6	"	.183436	80	375	11250	562	10688	58265	
18	.760	.244	.185440	7	"	.183678	80	375	11250	562	10688	58189	
19	.760	.244	.185440										
20	.760	.243	.184680	8	"	.183540	80	378	11340	567	10773	58696	
21	.759	.243	.184437										
22	.759	.240	.182160										
23	.759	.241	.182919	9	"	.182970	80	378	11340	567	10773	58878	
24	.759	.241	.182919										
25	.760	.241	.183160										
26	.763	.239	.182357										
				10	July 18,	.180863	76	221	6630	331	6299	34827	
Mean of 27=			.183439										
				11	"	.180475	76	234	7020	351	6669	36952	.456
Maximum=			.186200	12	"	.182892	76	234	7020	351	6669	36464	
Minimum=			.178935	13	"	.182350	76	236	7080	354	6726	36885	
				14	"	.182919	76	236	7080	354	6726	36770	
Mn. of the 2			.182567										
Diff. of the 2			.00725		Mn. of 14 =	.182912							

TABLE LXXIII.

reduced by filing to a nearly uniform size, marked and gauged at every inch. Specific gravity 7.8046.

Thickness after frac.	Area after fracture.	Area after, in parts of that before, fracture.	Point of fracture.	REMARKS.
.150	.077700	.421	No 20½	Part in tin from 1½ to 5½. Before the fracture the part from No. 7 to 20 was found to be 15 3-10 inches long, and had consequently stretched 2 3-10 inches or a little more than 1-6 of its original length.
			" 17¼	Broke at the remotest part from the tin which is still in the same place as above.
			" 14	
			" 12¼	Fracture very near the wedges. This experiment would by calculating on the smallest section in tin give a strength of 54058 lbs. per square inch.
			" 1	Reduced in area at No 1. But not actually broken. It had borne 360 lbs. while at a temperature of 570°. The smallest section in tin, which is the smallest in the bar, is the one on which the calculation is made in the table.
			" 9½	Broke soon after applying the weight.
			" 8	Yielded very gradually.
			" 6¾	
			" 5¾	The part remaining after this experiment from 0 to No. 5 had become 5.93 in. in length. Extension $=\frac{1}{3.377}$ of the original length.
			" 2¾	From this experiment to the end of the series, the trials were on annealed sections.
.130	.059280	.328	" 0½	
			" 25½	
			" 22½	
			" 23½	

The mean area of the 14 sections of fracture is .000527 square inch *less* than that of the 27 measured sections.

TABLE LXXIV.

Experiments on bar No. 224 E. Manufactured by Messrs. Yeatman & Woods, at Nashville, Tennessee. Drawn by the hammer,

Marks.	Breadth.	Thickness.	Area before trial.	No. of the experim't.	DATE.	Area of the section of fracture before trial.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.
0	.753	.243	.182979		1833.					
1	.753	.239	.179967	1	July 11,	.178224	566°	305	9150	457
2	.753	.238	.179214							
3	.752	.238	.178976	2	"	.178105	570	319	9570	478
4	.752	.237	.178224							
5	.752	.238	.178976	3	"	.178976	554	329	9870	493
6	.750	.237	.177750							
7	.753	.237	.178461	4	"	.177562	573	334	10020	501
8	.753	.236	.177708							
9	.749	.237	.177513	5	"	.178976	560	351	10530	526
10	.752	.237	.178224							
11	.752	.237	.178224	6	"	.178047	560	351	10530	526
12	.753	.237	.178461							
13	.752	.237	.178224	7	"	.178698	560	367	11010	550
14	.754	.236	.177944							
15	.754	.237	.178698	8	"	.179468	82	322	9660	483
16	.754	.237	.178698							
17	.754	.237	.178698	9	July 12,	.178976	82	375	11250	562
18	.754	.237	.178698							
19	.750	.236	.177000	10	"	.180480	82	385	11550	577
20	.751	.236	.177236							
21	.752	.240	.180480	11	"	.177059	82	394	11820	591
22	.752	.240	.180480							
23	.752	.240	.180480	12	"	.180480	82	394	11820	591
24	.751	.240	.180240							
25	.752	.238	.178976	13	"	.173342	82	383	11490	574
26	.752	.238	.178976							
				14	"	.178342	82	383	11490	574
	Mean of 27		.178870							
				15	"	.178321	82	397	11910	595
	Maximum		.182979		Mean of 15=	.178337				
	Minimum		.177000							
	Mn. of these 2		.179989							
	Diff. of the 2		.005979							

TABLE LXXIV.

reduced by filing to a nearly uniform size, marked and gauged at every inch from **0** *to* **26**, *inclusive. Specific gravity*, **7.8046.**

Effective strain.	Strength in lbs. per square inch.	Point fractured.	REMARKS.
8693	48776	No. 4	Part in tin from 16 to 20. This was therefore a cold fracture.
9092	51048	" 6½	Cold fracture.
9377	52392	" 26½	Cold fracture.
9519	53576	" 8¾	Warm at the section of fracture. On the opposite part of the bar to the preceding.
10004	55896	" 25¾	Broke near the wedges.
10004	56287	" 9¾	Broke near the wedges, on the side of tin bath opposite to that of the preceding fracture.
10460	58534	" 18	Broke in tin.
9177	51134	" 1¾	This piece had been broken off in the first experiment on the bar.
10688	59662	" 25	
10973	60799	" 22½	
11229	63419	" 19¼	
11229	62273	" 21¼	
10916	61208	" 11½	Different piece from the preceding.
10916	61208	" 12½	
11315	63453	" 14½	
			The mean area of the 15 sections of fracture is .000533 *less* than that of the 27 measured sections.

TABLE LXXV.

Experiments on bar No. **231**, *Russian iron. Obtained from Messrs. Jackson & Riddle, iron merchants of Philadelphia. Reduced by ham-*

Marks.	Breadth.	Thickness.	Area before trial.	No. of the exp't.	DATE.	Area of the section of fracture before trial.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.	Strength in lbs. per square inch.
1	.800	.239	.191200									
2	.800	.238	.190400									
3	.800	.238	.190400									
4	.799	.244	.194956		1834.							
5	.799	.242	.193358	1	Aug. 9,	.193437	72.°	465	13950	697	13253	68513
9	.798	.240	.191520									
7	.800	.237	.189600	2	"	.191600	72.5	518	15540	777	14763	77051
8	.800	.241	.192800									
9	.797	.240	.191280	3	"	.192800	72.5	518	15540	777	14763	76571
10	.800	.235	.188000									
11	.800	.238	.190400	4	"	.193891	72.5	540	16200	810	15390	79374
12	.800	.239	.191200									
13	.800	.240	.192000	5	"	.198800	73.	525	15750	787	14963	78835
14	.798	.237	.189126									
15	.798	.236	.188328	6	"	.189837	574.	514	15420	771	14649	77166
16	.800	.236	.188800									
17	.800	.237	.189600	7	"	.189126	75.	588	17640	882	16758	88607
18	.800	.237	.189600									
19	.801	.237	.189837	8	"	.188328	75.	609	18270	913	17357	92163
20	.801	.237	.189837									
21	.800	.239	.191200	9	"	.189629	75.	643	19290	964	18326	96641
22	.798	.237	.189126									
Mean of 22			.190980	Mean of 9		.191938						
Maximum			.194956									
Minimum			.188000									
Mn. of the 2			.191478									
Diff. of the 2			.006956									

TABLE LXXV.

mering and filing in the usual way. Specific gravity, **7.8014.**

Specific gravity of the parts in the vicinity of the section of fracture.	Point fractured.	REMARKS.
		The first permanent elongation perceived, was taken under a weight of 308 lbs.
7.7945	No. 3 3/8	This fracture developed a seam or flaw in the direction of the *length*.
7.7985	" 12 1/2	Fracture smooth and fine, but not entirely uniform.
7.8231	" 8	Took off 14 lbs. of the weight used in last experiment, and restored them gradually.
7.8702	" 4 3/8	Broke in the gripe of the wedges.
7.7586	" 10 3/4	
7.8307	" 19 1/8	
7.8211	" 14	This fracture presented a steely or crystalline appearance.
7.7650	" 15	Do. (in part.)
7.7831	" 18 1/8	Do.
End piece. 7.7696		
Mn 7.8014		
		The mean area of the 9 sections of fracture was *greater* than that of the 22 measured sections, by .000958 square inch, which is one half of one per cent. of their mean magnitude.

TABLE LXXVI.

Experiments on bar No. **232**, *Swedish iron. Obtained from Messrs. Jackson & Riddle,—taken at random from a large number—slit with the chisel lengthwise, and then reduced by hammering and filing to a*

Marks.	Breadth.	Thickness.	Area before trial.	No. of the experiment.	DATE.	Area of the section of fracture before trial.	Temperature, Fah.	Breaking weight.	Breaking wht. × leverage.	Friction.	Effective strain.
1	.801	.234	.187934								
2	.801	.234	.187934		1834.						
3	.801	.233	.186633	1	Septem.	.187872	72	376	11280	564	10716
4	.800	.233	.186400								
5	.800	.234	.187200								
6	.800	.234	.187200	2	"	.187798	72	393	11790	589	11201
7	.800	.232	.185600								
8	.800	.232	.185600								
9	.800	.233	.186400	3	"	.186809	947	313	9390	469	8921
10	.800	.234	.187200								
11	.800	.233	.186400								
12	.800	.233	.186400	4	"	.185262	56	457	13710	685	13025
13	.800	.232	.185600								
14	.802	.232	.186064	5	"	.186599	56	464	13920	696	13224
15	.802	.233	.186866								
16	.802	.231	.185262	6	"	.186400	56	464	13920	696	13224
17	.802	.231	.185262								
18	.802	.232	.186064	7	"	.187200	56	461	13830	691	13139
19	.808	.233	.188264								
20	.807	.233	.188031	8	"	.186400	56	468	14040	702	13338
21	.801	.233	.186633								
22	.803	.233	.187099	9	"	.187434	55	474	14220	711	13509
23	.803	.233	.187099								
24	.803	.233	.187099	10	"	.186600	55	479	14370	718	13652
25	.806	.233	.187798								
26	.807	.235	.189645	11	"	.188089	55	406	12180	609	11571
27	.807	.233	.188031								
28	.803	.234	.187872	12	"	.187565	55	434	13020	651	12469
29	.802	.234	.187668								
30	.803	.234	.187872	13	"	.187099	55	462	13860	693	13167
31	.805	.232	.186760								
					Mn. of 13 =	.187009					
Mean of 31			.186935								
Maximum			.188264								
Minimum			.185600								
Mn. of the 2			.186932								
Diff. of the 2			.002664								

TABLE LXXVI.

{*suitable size for the experiments. Specific gravities of the different sections as in the last column, mean of* 6 *trials*, 7.4587.

Strength in lbs. per square inch.	Point of fracture.	REMARKS.
57039	No. 28	First perceptible elongation taken with 196 lbs. in the scale. Specific gravity of the end part, 7.6106.
59644	" 25	With 380 lbs., 24 inches in length had become 25 *nearly*.
52401	" 18⅓	Used the pyrometer with a new screw and revolving weight. Each degree weighs 4–7 of a grain of steam. Specific gravity 7.5118.
70030	" 16	
70868	" 14⅔	Specific gravity 7.4414.
70965	" 11	
70186	" 5½	
71555	" 9	
72073	" 1⅔	
73161	" 4½	Specific gravity 7.5052.
61518	" 19⅔	Specific gravity 7.367.
66478	" 20½	Specific gravity 7.3133.
70376	" 22⅔	The mean area of the 13 sections of fracture is .000074 square inch *greater* than that of the 31 sections measured before trial.

TABLE LXXVII.

Experiments on bar No. **233.** *Swedish iron. Reduced to uniform size as in the preceding table. Specific gravity, by a mean of* **7** *trials on*

No. of the mark.	Breadth.	Thickness.	Area of sections measured before trial.	No. of the experim't.	DATE.	Area of the section of fracture before trial.	Temperature, Fah.	Weight in the scale.	Weight × leverage.	Friction.
1	.802	.226	.181252		1836.					
2	.800	.227	.181600	1	April 16,	.181178	65°	371	11130	556
3	.800	.226	.180800							
4	.806	.226	.181478							
5	.803	.225	.180675	2	"	.179424	65	363	10890	544
6	.804	.227	.182508							
7	.803	.227	.182481							
8	.802	.227	.182054	3	"	.181252	650+	336	10080	504
9	.802	.227	.182054							
10	.802	.227	.182054							
11	.801	.226	.181026	4	"	.181653	50	403	12090	604
12	.802	.224	.179648							
13	.802	.226	.181252							
14	.801	.225	.180225	5	"	.180348	50	403	12090	604
15	.801	.225	.180225							
16	.801	.225	.180225		1837.					
17	.801	.225	.180225	6	Jan. 5,	.180225	530	378	11340	567
18	.801	.225	.180225							
19	.801	.225	.180225							
20	.802	.225	.180450	7	"	.180225	40	426	12780	639
21	.802	.225	.180450							
22	.802	.224	.179648							
23	.802	.226	.181252	8	"	.180450	40	413	12390	619
24	.802	.227	.182054							
25	.802	.226	.181252							
26	.801	.227	.181827	9	"	.180225	40	420	12600	630
27	.798	.226	.180348							
28	.799	.227	.182373							
29	.800	.226	.180800	10	"	.181252	40	408	12240	612
30	.801	.224	.179424							
31	.800	.226	.180800							
				11	"	.181026	40	399	11970	598
	Mean of 31		.181187							
	Maximum		.182508	12	"	.182394	40	408	12240	612
	Minimum		.179424							
	Mean of the 2		.180966	13	"	.182054	40	413	12390	619
	Diff. of the 2		.003084							
					Mean of 13	.180900				

TABLE LXXVII.

different parts of the bar, 7.4983.

Effective strain.	Strength in lbs. per square inch.	Point of fracture.	REMARKS.
10574	58362	No. 4⅜	Short piece only embraced between the heads of the machine.
10346	57662	" 30	Shorter portion than before.
9576	52838	" 23	In hot metal above 650°.
11486	63230	" 24½	
11486	63688	" 27	
10773	59775	Not bro.	Tried in tin from 16 to 19. Not broken. Elongation on the part in tin, after trial, .25 inch.
12141	67365	" 17¼	
11771	65231	" 20¼	
11970	66417	" 15	
11628	64153	" 0½	
11372	62819	" 11	
11628	63203	" 6½	
11771	64656	" 8¼	The mean area of the 13 sections of fracture is .00287 *less* than that of the 31 sections measured before trial.

TABLE LXXVIII.

Experiments on bar No. 237, a specimen of bar iron manufactured by H. A. Grubb and heirs, Lancaster County, Pennsylvania. Ore taken

Marks.	Breadth.	Thickness.	Area of the section measured before trial.	No. of the experiment.	DATE.	Area at the section of fracture before trial.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.	Strength in pounds per square inch.	Breadth of section after fracture.
1	.795	.250	.198750										
2	.793	.250	.198250										
3	.796	.250	.199000		1835.								
4	.797	.250	.199250	1	July 18,	.195624	56½°	392	11760	588	11172	57109	.628
5	.796	.250	.198500										
6	.796	.252	.200592										
7	.796	.252	.200592										
8	.794	.252	.200088	2	July 24,	.198792	83	420	12600	630	11970	60213	.621
9	.791	.250	.197750										
10	.790	.251	.198290										
11	.794	.251	.199294	3	"	.198334	83	431	12930	646	12284	61935	.648
12	.794	.251	.199294										
13	.792	.247	.195624										
14	.795	.251	.199545	4	"	.199125	83	436	13080	654	12426	62403	.640
15	.795	.250	.198750										
16	.791	.246	.194586										
17	.796	.246	.195886	5	"	.200592	83	448	13440	672	12768	63651	.640
18	.792	.252	.199484										
19	.792	.252	.199484										
20	.794	.250	.198500	6	"	.198750	575	408	12240	612	11628	58508	.668
21	.795	.251	.199545										
22	.795	.249	.197955										
23	.796	.247	.196614	7	"	.199015	110	424	12720	636	12084	60719	.663
Mean of 23=			.198502										
				8	"	.195016	100	434	13020	651	12369	63396	.619
Maximum			.200592										
Minimum			.194586										
				9	"	.198110	100	452	13560	678	12882	65024	.632
Mean of the 2			.197589										
Diff. of the 2			.006006		Mn. of 9 =	.198151							

TABLE LXXVIII.

from the Cornwall ore-bank. Drawn under the hammer, reduced by filing and gauged at every inch. Specific gravity, 7.740.

Thickness after fracture.	Area of section after fracture.	Area *after* comp. with that *before* trial taken as unity.	Point of fracture.	REMARKS.
.178	.111784	.571	No. 13	The load first tried in making this experiment was 363 lbs., which the bar bore for some time, but on changing it for 392 it gave way very soon—result supposed to be a little too high—part in tin from 4 to 7 inclusive.
.181	.112401	.565	" 10½	
.192	.124416	.627	" 8¾	
.195	.124800	.626	" 3½	
.199	.129360	.644	" 7	
.200	.123600	.621	" 21½	Part in tin from 16½ to 21. The temperature of the section of fracture at the moment of breaking was judged to be not less than 400°.
.186	.123318	.619	" 14⅔	
.178	.110182	.565	" 15⅞	
.199	.125768	.634	" 17⅝	
		.608		The mean area of the 9 sections of fracture is .000350 square inch *less* than that of the 23 measured sections.

Results of experiments on wrought iron not rolled into plate.

Among the facts disclosed in this range of results, those respecting English cable-bolt iron, are given in tables LXI., LXII. and LXIII. But much of the matter in the first two of these tables, refers to the influence of high temperatures. They, however furnish a mean result, on bar 214, for the strength in the cold state, of 57987 pounds to the square inch. On bar 212, an experiment, on a deeply filed section, gave 59975, while two trials on 213 gave a mean of 59351 pounds. Hence the mean of these three results, viz: 59105 pounds, represents the strength of the best English cable-bolt iron under ordinary circumstances. Table LXIII. presents the results on two portions of the above iron, one cut from bar 213, the other from 214, and on these portions, the effect of *hammer-hardening* was tried. The bars when drawn out under the hammer, previous to being filed down, were hammered until nearly, or quite, cold. It will be seen that the lowest result on these two specimens was 65718, the highest 75045, and the mean of eight trials, 71000 pounds. From this statement, it is apparent that the process applied augments, very sensibly, the tenacity of the material; for the lowest result in this table, is 5743 pounds, or 9.5 per cent., above the highest of the three just detailed, as given by the metal in its ordinary state; while the mean of the hammer-hardened specimens, is 11282 pounds or 19.2 per cent. above the mean strength of those which had been only hammered out in the ordinary way, and left to cool off from a red heat without the simultaneous application of any mechanical action.

Table LXIV. contains the experiments on a specimen of wire, about one-third of an inch in diameter. The maximum strength at 50°, is 88354 pounds per square inch, the minimum 72325, (the latter being on a part annealed before trial,) and the mean of all the trials 81387.

Experiments 3, 4, 5, and 6, on this wire, gave results so nearly identical, that we may perhaps more properly assume their mean as its true average strength, equal to 84186 pounds per square inch, at from 60 to 66 degrees Fahrenheit. From *this* mean the diminution by annealing, is 14 per cent.

By the first 5 experiments, in table LXXV., it appears that the strength of Russian bar iron, at ordinary temperatures, is 76069 pounds per square inch. It will be perceived that the specific gravity of this specimen is considerably higher than that of most other samples of metal, which we have examined. Its superiority in point of tenacity is, probably, attributable, in a great degree, to the refining process to which it had been subjected. The fracture was of a peculiarly fine, fibrous appearance, and had generally a tolerably regular bevel or *chisel* edge, across the *thickness* of the bar.

In the tables numbered from LXV. to LXIX., will be found an account of experiments on 5 bars of iron, manufactured in Missouri; and in those numbered from LXX. to LXXIV., are recorded the operations on the same number of bars made near Nashville in Tennessee. In the case of these, as well as other bars on which some of the trials were marked as at elevated temperatures, the fractures often took place at points so remote from the source of heat, that the results really belong to "ordinary temperatures." Including fractures made under the circumstances just alluded to, the number of results obtained at those temperatures, on the Missouri iron, is 22, and the mean strength 47909 pounds per square inch. On the Tennessee iron, were made, under similar circumstances, 21 experiments, giving a mean strength of 52099 pounds. The Missouri bars appeared to possess a coarse fibrous structure, and were judged to have undergone but little refining in bringing the metal to a malleable state.

Table LXXVIII. exhibits the tenacity of iron manufactured by Messrs. Grubb, of Lancaster county, Pennsylvania, as 58561 pounds per square inch.

While on this subject, we may refer to some following tables of experiments on iron from Salisbury, Connecticut, manufactured from different sorts of pig-metal, reserving, however, the particular discussion of those tables to a subsequent section of this report. It will be found on inspecting table LXXIX. that forty experiments, at comparable temperatures, were made on the materials from that quarter, the mean result of which is a strength of 58009 pounds per square inch.

In connexion with the present topic, may also be mentioned the result of experiments on specimens of iron manufactured in Centre County, Pennsylvania, an account of which will be found in table XCVII. The mean strength of three bars, as given by 15 experiments, is 58400 pounds. Table CII. includes, among others, 10 experiments, at ordinary temperatures, on Phillipsburg wire of smaller sizes than that already mentioned. Of these, the larger,—.19 inch in diameter—will be found to have exhibited, at 5 trials, a mean strength of 73880 pounds; and that which had a diameter of .156 inch, a strength of 89162 pounds per square inch.

Collecting together the forogoing details, we have for the strength

Of Missouri bar iron, at ordinary temperatures, by		22 exp.	47909 pounds.
Slit rods, (Nos. 180 and 182.)		2	50000
Tennessee bar,		21	52099
Salisbury, Conn.,		40	58009
Swedish bar,		4	58184
Centre Co., Pa.,		15	58400
Lancaster Co., Pa.,		2	58661
English Cable iron,		5	59105
Do. hammer hardened,		8	71000
Russian bar,		5	76069
Phillipsburg wire, diam.	.333	13	84186
	.190	5	73888
	.156	5	89162
Cast steel, (Table LIX.)		1	130681

[TO BE CONTINUED.]

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Remarks on the mode of Gearing Mills for the Manufacture of Cotton and Woollen Goods. By I. H. BEARD, Civil Engineer.

Throughout New England, until within a few years, it was generally thought by Engineers and Millwrights that cotton mills, and woollen mills, and all others, requiring a very considerable power, could not be run effectively without large and ponderous lines of upright, and horizontal shafts of either cast or wrought iron, and heavy trains of cog-wheels of cast iron, or partly of iron and partly of wood. And when large leather belts began to be introduced for the main gear of mills, as a substitute for gear-wheels, it was thought by some of our best Engineers to be an experiment, at the least, of very doubtful result, if not altogether impracticable; and, indeed, at the present time, notwithstanding all the evident advantages of belts over gear-wheels, many still adhere to the old mode of gearing; and this, doubtless, not so much from a want of discernment, and sound judgment, as from a

lack of opportunity of comparing and testing the advantages of belts, and the disadvantages of gear-wheels; or, perhaps, they may have formed an erroneous opinion of the utility of using belts from the inspection of some mills, that have been belted on a bad principle, or from belts injudiciously managed.

Having, from a constant practical experience of both modes of gearing mills, for more than ten years, at Lowell, Saco, and other places, become fully satisfied of the utility of belting mills, instead of running them with gear-wheels, and that they run much lighter, stiller, and with far less friction, and a proportionally less motive power, with belts than with gear-wheels, I have thought a few hints on the subject might be interesting to some of the readers of the Journal.

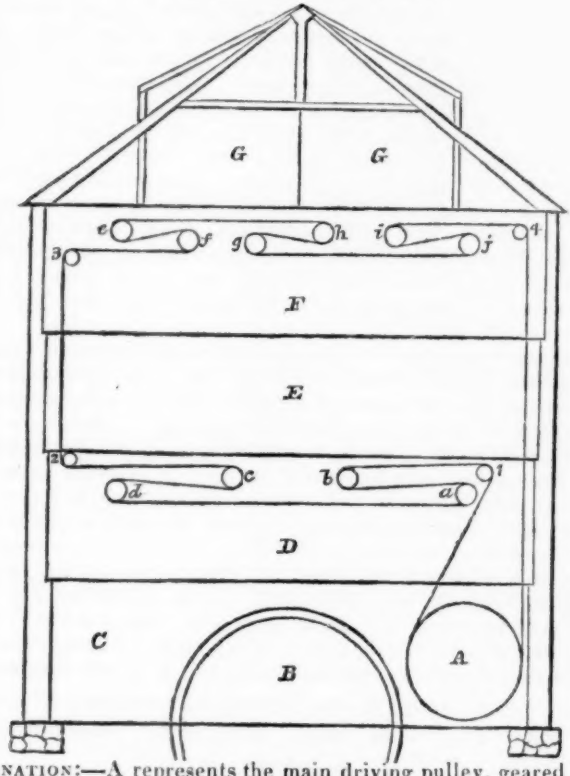
A cotton mill of dimensions adapted to the convenient operation of 4000 spindles, of cotton machinery, including all the preparation for making yarn, and weaving cloth, ordinarily, required four trains of upright shafts, extending through the height of four stories, the trains usually commencing in the basement story.

To each train of uprights were attached from two to four pairs of heavy gear-wheels, and in addition to these, in many mills all the counter lines of shafts were geared off at right angles with the horizontal main shafts, which required a very large number of gears and shafts. A mill thus geared is a full load for the power of a moderate sized water-wheel without any machinery, and a great proportion of this unnecessary weight and friction may be saved by the judicious use of belts instead of gears. And besides the disadvantages before named, the trains of gear-wheels require the constant extra expense of careful attendance, and of oil or some unctuous matter to lubricate and keep them from heating, friction, and rapid abrasion. And again, all the gears must be closely boxed in, and supplied with tight dripping pans, or the mill-grease will be liable to drop into the work and greatly damage, if not entirely ruin it. These are serious inconveniences and evils that may be avoided by substituting belts in the place of gear-wheels. The first expense, and the constant repairs will be as little with belts as with gear-wheels; and the risk and hindrance that may be caused by belts is far less; for if a main belt breaks, it is the work of a few minutes only, to repair it or replace it with a new one, whereas, the breakage of a single gear-wheel may cause the hindrance of a week, and the almost entire loss of the wheel broken, together with a hundred times the labour and expense in exchanging the broken wheel for the new one, that would be caused in repairing or exchanging the belts. And again, if it should be found desirable, at any time to change the velocity of any part of the mill gear, it is much more easily done, and with far less expense, by varying the size of the pullies and drums than by changing gear-wheels.

But to gear a mill wholly with belts, and to do it judiciously, and to the best advantage, doubtless requires more nice calculation, careful judgment, and practical experience, than to do it with gear-wheels; for many mills have been so belted as to cause more friction, trouble and expense than would be caused or required in the use of gear-wheels. Therefore, to enable those who may wish to calculate mill-gear, and who may not have had the means of forming a correct judgment by practical experience, to judge correctly of the advantages as well as of the disadvantages of several modes of gearing, I shall first introduce two or three such modes as I consider objectionable, and then bring forward a mode that I consider the least objectionable, and the best now in use. To know how to avoid an evil is frequently as

beneficial as to know how to remedy it. Therefore, let me first bring forward one or two objectionable modes of belting to enable me the more clearly to illustrate the advantages of what I suppose to be the best and least exceptionable mode of operation.

Elevation of a Cotton Mill.



EXPLANATION:—A represents the main driving pulley, geared from, and driven by the water-wheel; and is made from eight to twelve feet in diameter. B, water-wheel; C, basement; D, carding room; E, spinning room; F, weaving room; G G, dressing room.

a, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *j*, represent the lines of drums in the carding and the weaving rooms. These lines of drums extend very nearly the whole length of the mill inside, and for a mill of 4000 spindles, are driven by two belts operating in the same manner. 1, 2, 3, 4, represent the belt-binders to lead, or bind, the belt in the required directions. The belt here represented must be about 320 feet long, and from 12 to 15 inches wide, and will require from 600 to 700 pounds of stout belt leather to make it. These belts are bulky, ponderous and unmanageable; and whenever a lacing breaks, to which accident they are frequently liable, they are likely to run nearly, or quite off, of the drums, and it would cause the hindrance of the whole work of the machinery, and the work of some half a dozen men half a day to put one of them on again.

But this is not the greatest evil. In passing the drums, the whole stress

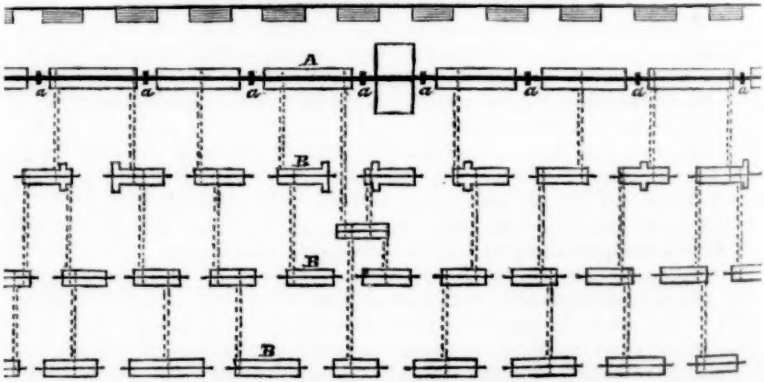
upon the belt is thrown upon the journals of the shaft of each drum the belt passes, which, besides greatly increasing the power required to operate the mill on account of the multiplied friction, causes the journals to heat and wear beyond the power of any lubrication to prevent; I have seen them heated so much as to render it indispensable to pour on cold water to cool them. To show more clearly the stress upon each belt and drum:

The power of seven mills in Lowell, Mass., containing 32,000 spindles, was equal to 330,000 pounds raised one foot a second; that is, the machinery 287,000, and the mill-gear 43,000 pounds. This gives for the stress on one belt carrying 2,000 spindles, equal to 20,625 pounds, raised one foot a second, or 1,237,500 pounds raised one foot a minute, which (estimating a horse-power at 32,000 pounds) is equal to very nearly 39 horse-powers required to operate 2,000 spindles with the other accompanying machinery, and the mill-gear, in a mill geared to the best advantage for economizing power; —and in a mill belted like the foregoing, the increase of power required to overcome the extra friction cannot, in my opinion, be less than thirty-three and a third per cent., which will make it require, to operate a mill thus geared, twenty-six horse-power to every thousand spindles, and fifty-two horse-power to each belt.

In laying out the gear of a mill, it is worth much time and pains to arrange the drums and belts in such a manner that, so far as may be practicable, the stress of one belt upon the journals shall be counteracted by that of another belt in an opposite direction, referring to the stress upon the line of main-drums, the counter-drums being of minor consequence; but where the main power is to be exerted, to throw the stress upon one belt into that of another, is economy in the wear of the whole mill-gear, as well as in power, both of which are points of great importance to the manufacturer. This point has not always been observed; for it is sometimes more convenient in arranging the gear and machinery of a mill to place the line of main drums upon one side of the mill instead of the centre. And the effect of this arrangement is to throw the whole stress of the belts upon one side of the journals of the main drum shafts, which ought ever to be avoided.

The following diagram represents a room belted in that manner.

Plan of the drums of a Carding-room.



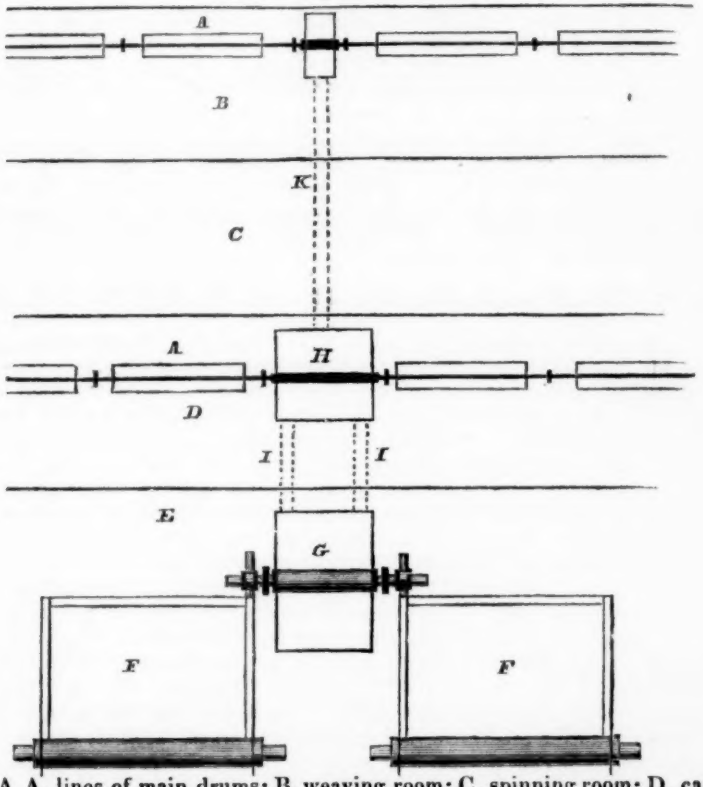
A, line of main drums; *a*, couplings of main shaft; B B B, counter drums; belts drawn with dotted lines.

This sketch is not laid down with reference to the arrangement of machinery of any kind, but merely with a view to show a particular mode of belting which has been disadvantageously adopted in some mills.

It is presumed that a single glance of the eye at this plan will show the ill effects of the arrangement without any further illustration.

The following elevation and plan will represent a mode of gearing with belts in which the stress is as nearly equalized as is practicable, and causing the least possible waste of power and wear of journals by friction, the stress upon one main belt being counteracted by that upon another in an opposite direction, and thereby throwing the power of one belt into its opposite, instead of the bearings of the main line of drums from which the whole power of the mill is taken.

Elevation of a Cotton Mill.



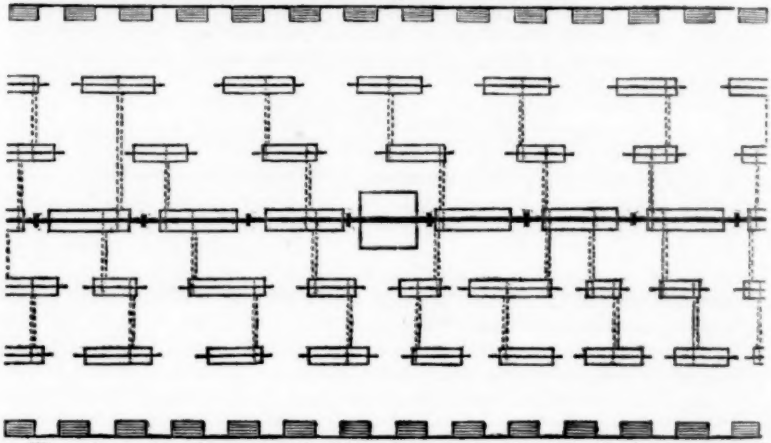
A A, lines of main drums; B, weaving room; C, spinning room; D, carding room; E, basement; F F, water wheels; G, main pulley; H, carding and spinning main pulley; I I, belts; K, belt to drive weaving and dressing.

In this elevation the two main belts, from the main pulley, sustain the whole power of the mill. Two such belts from 12 to 15 inches wide, made of the best of stock, are capable of operating 4,000 throstle spindles, with all the accompanying machinery for manufacturing coarse, heavy cotton goods.

The single belt from the carding main pulley carries the weaving and dressing only, and a belt twelve inches wide is amply powerful for that purpose, even if made of lighter leather than the two belts from the main pulley.

In this mode of belting the power of the weaving and dressing main belt is made to act against the stress of the first two belts, and, in a good measure, to relieve the bearings of the carding and spinning main pulley.

The following is a plan for relieving the lateral stress.



The above plan is arranged with reference to showing the best mode of belting to relieve the bearings from friction. This object being attained, it is further of great importance that each belt should be of such a length that it will adhere to the drum so much as to prevent it from slipping, and that without the necessity of pulling on the belt so tight as to cramp the drums and wear the bearings. Every belt, to run easy and well, should be so slack, when running, that the slack side should run with a waving, undulating motion, without any tension except on the leading side, and when belts will so run without slipping upon the drums or pullies they will wear for a great length of time; for although a belt may be heavily loaded, yet, if, at every revolution, it can have an opportunity for relief from its tension so as to contract to its natural texture, it will prevent it from breaking by the stress upon it. But if, otherwise, it be kept strained so tensely as to be constantly strained to its greatest extent on both sides of the drums, it will wear but a short time without cracking at the edges, and will shortly be destroyed.

Sufficient care is seldom taken to have belts to run free and easy, and it has been one of the greatest errors, more or less prevalent in all cotton and woollen mills, to run the belts so tense as greatly to injure the belts and rapidly increase the wear of the bearings.

It has been customary in almost all belted mills to affix heavy cast iron, or wooden binders, weighted, to the belts which drive the main mill gear, to prevent them from slipping, and it has been generally thought impracticable to keep them from slipping on the pullies and drums without binders; but this opinion is wholly erroneous, and without any true foundation, if the belts are properly prepared. This point I have tested and proved to a demonstration in a cotton mill at Pittsfield, N. H.

This mill contained 3072 spindles of throstle spinning and all the preparation and other machinery for manufacturing coarse shirtings. While I had charge of the mill I geared it entirely anew, and in the manner described on pages 455 and 456. The whole mill was driven by two belts only, twelve inches wide, and with no binders; and every belt in the mill was run very slack and perfectly easy on the drums, and without the least loss by slipping.

The method taken to make them run light and slack without slipping, was as follows; and the plan succeeded so well that every manufacturer who uses belts, ought to know it.

I prepared my belts by stuffing them, after they were completed, with a composition of common tallow, bayberry tallow, and beeswax, in the following proportions, viz: two pounds of common tallow to one pound of bayberry tallow, and one pound of beeswax.

I melted the ingredients in a kettle placed over a furnace of charcoal, and heated the composition to the boiling point, and kept it boiling while applying it to the belts. I put it upon both sides of my belts with a brush, the leather being perfectly dry; and notwithstanding the composition was so hot, the wax did not strike into the belt, but a great proportion of it was left on the surface. I then filled a small iron box stove with charcoal and set it on fire, and when the stove was at nearly a red heat, I moved the belts slowly over the top, and within half an inch of the stove, and by this means heated the leather so as to cause the wax to strike into it. I was at first apprehensive of burning the leather with the degree of heat applied, but I have since found that there is not the least danger of it if the leather is perfectly dry.

To test the degree of heat the dry leather would bear without burning, in the composition, I placed a kettle of it over a blacksmith's fire, and after melting it, I put in a coil of two inch belting, about sixteen feet long and boiled it forty-five minutes with the greatest degree of heat I could produce by blowing the fire continually, and the belt, when taken out, was not in the least injured by the heat of the composition. I then tried a piece of belting damped with water, and it burnt and crisped in less than half a minute.

I have found that, by stuffing belts in this manner, I could work up my stock much closer, for the composition enters into and fills up the thin, porous and spongy parts of the leather, and renders them nearly as firm and durable as the best of the leather cut from the back of the side.

In gearing a mill, after cutting the sides of leather as close as I deem profitable, I take the remaining thin parts, which are ordinarily considered of very little value, and stuff them in the same manner as I do the belts and cover all the drums and pullies where the belts are to run, putting them on with the grain side out, and securing them in place with common shoe pegs. Nails are not good for this purpose, for they will work out so as to injure the belts. I then put the belts on to the drums and turn the grain side of the leather in, so that the two grain sides run together. The advantage derived from reversing the grain sides of the leather in contact, instead of the flesh sides, is, that their surfaces are more even, and when well stuffed with the composition, they are so close in contact as very nearly to exclude all the air from between them, and then the pressure of the surrounding air causes them to adhere so firmly that a belt would break, if running at a high velocity, before it would slip on its bearings.

To show, in pounds, the power of the atmosphere on a belt, let us assume a

pulley of 4 feet diameter with a 12 inch belt bearing on half of its circumference.

Then $4 \times 3.1416 = 12.5664 \div 2 = 6.2832$ feet, equal to 75.4 inches, nearly.

And $75.4 \times 12 = 904.8$ square inches of surface in contact.

Multiplying by the pressure of the atmosphere (15 pounds to a square inch) gives $904.8 \times 15 = 13572$ pounds pressure upon the belt.

A belt adheres much better and is less liable to slip when it runs at a quick speed than at a slow speed.

Therefore, it is much better to gear a mill with small drums and run them at a high velocity, than with large drums, and to run them slower; and a mill thus geared costs less and has a much neater appearance, than with large heavy drums; and, in belting, if the power of a belt 18 inches wide were required it would be much better to put in two 9 inch belts than one so wide, for it is extremely difficult to find leather that will hold its thickness for a very wide belt, so that one side of the belt shall not be thinner than the other, and this inequality will cause the thin side of the belt to stretch and become longer than the other, making that edge of the belt loose upon the drum, and thereby destroying the principle of adhesion, and causing the loss of a great proportion of the power of the belt.

In many mills a practice prevails which is very injurious to the durability of the belts, and ought to be abandoned. That is, the practice of applying currier's oil, or neat's foot oil to the belts, to prevent them from slipping; for the oil opens the pores of the leather, destroys the adhesion of its parts, and, in a very short time, renders it flaccid and rotten, and a belt will not last half so long stuffed with oil as with the composition before named. The experiment is easily tried, and it will prove to any one's satisfaction the truth of this statement.

I am of opinion that engine hose is frequently destroyed more by the use of neat's foot oil than by time and use, and that its durability, generally, might be greatly prolonged if the leather were stuffed with wax and tallow before it is made up, and then occasionally applied after it is put into use.

There are other advantages in the use of this composition: it not only preserves the leather, and keeps it firm, and at the same time flexible, and perfectly pliable, but it does not require half the expense of time in the application that oil does; for belts stuffed with the composition will run well for six months without glazing so as to need a new application.

This composition is impervious to water, and, on that account, is an excellent article for boots and shoes, as well as for engine hose.

I once tried the experiment with a pair of boots, made of a calf-skin curried and finished without a particle of unctuous matter of any kind; and after the boots were made I stuffed them in the same manner that I do my belts (with the addition of a little ivory black to the composition) and roasted them by a fire until the leather, both soles and tops, were completely saturated; and there never was a particle of oil applied to them, and they were always impervious to water, and their durability exceeded any boots I ever wore.

If the foregoing hasty remarks shall prove of any service to the public, I shall feel amply rewarded for my time in preparing them.

Observations on the duty performed by the Cornwall Steam Engines. By Jacob Perkins, Civil Engineer.

Read before the Institution of Civil Engineers.

No. II.

If indisposition had not prevented my attending the Society I certainly should not have neglected the opportunity of substantiating that part of my last paper, which was so decidedly denied, by one of the most scientific and practical members of the Institution.

I understood him to declare that the diagram which explained my views of the operation of the expansive property of high steam was altogether erroneous, and that to make out my case, I must assume the fact, that steam is a permanently elastic fluid. I do not admit that its change from an elastic to a non-elastic state is instantaneous; nor do I hesitate to declare that its elasticity is sufficiently permanent for all practical purposes. I assert also, from careful observations, and extensive experience, that there is no material fallacy in the diagram alluded to. It was further stated, by some one of the Society, that to maintain this expansive property of steam, increments of heat must be furnished from time to time, to restore the heat lost by, what the celebrated Mr. Watt called the "heat of expansion." That between the strokes of the piston, there is more or less heat lost by radiation, is an undoubted fact, but this is so trifling that it would not diminish the advantage of using high steam expansively to such an extent as to be noticed. But if Mr. Dalton is correct in his theory of steam (which I firmly believe) no further heat is called for. Dr. Dalton says that 37 atmospheres of steam require fifty times as much heat as a single atmosphere, if so, the supply would be abundant if the engine were surrounded by a non-conductor.

Mr. Watt believed that there would be a gain in using steam expansively, or he would not have taken out a patent for his discovery; Mr. W., however, abandoned it, for, as he applied it, no useful result was produced.

The fact was that Mr. Watt was an unbeliever in the safety of high steam, and never used it higher than four pounds to the square inch above the atmosphere, and seldom more than two; how it could have been expected that any material gain could have been shown by using such low steam is to me very strange.

It was said by another member that my experimental engine pumped but very little water.

It was no part of the experiment to show how much water could be pumped. Any one who has any practical knowledge in raising water by a steam engine, knows that the loss is very great when a small engine is used. The difference of area of the large Cornish pumping engine, and the little high pressure engine used at Saint Catherine's Docks, was as 126 to 1.

Can any Engineer point out how so many millions of pounds of water could be pumped one foot high with a bushel of coal, by means of so small an engine, thus performing the same proportional duty with the large Cornish engines. It has been often said by practical engineers, that any other mode of testing my engine than that of comparing it with the low pressure engine of the same power that I calculated mine to be, which was sixteen horse, and both doing alternately the same work, would be unsatisfactory.

It so happened that a sixteen horse low pressure engine was daily working at Saint Catherine's Dock, and after much difficulty, we obtained liberty to erect a shed and set up the little high pressure engine directly along-

side of the sixteen horse low pressure engine; that this low pressure engine was in good order, was known by the goodness of the vacuum. My friends and co-partners, who were extremely anxious to have the engine fairly tested, agreed to pay the expenses of the experiments (which proved to be above £150,) if I pumped *any* more water than the low pressure engine, if I did not, I was to be at the expense. The result was that they were perfectly satisfied that the engine did the same amount of work with less than a quarter of the coal required for the other engine.

If we are to make war against new and important facts, because they contradict old and apparently well established theories, we shall make but little progress in the advancement of the Arts and Sciences.

It appears to me that it is of the utmost consequence that the fact of the enormous saving of fuel, which the best Cornish engines undoubtedly show over the best Soho engines, should be honestly and fairly investigated with a view to ascertain the cause, and although old theories may seem to stand in the way of new facts, yet these facts should be allowed to have their due weight.

There appears to be several reasons given for the difference of duty obtained by the two systems.

First, The expansive property which highly elastic steam possesses when properly applied.

Secondly, The slowness of the stroke in the Cornish engines.

Thirdly, The greater fire surface of the boiler.

Fourthly, The dispensing with the fly-wheel, when pumping is the work to be done.

Fifthly, The diminished friction of the piston by the increased size of the cylinder, in consequence of its being a single stroke engine.

Upon strict inquiry, I find that the duty of the largest low pressure double stroke engine is 22,000,000 pounds raised one foot high with a bushel of coals; the utmost duty of a low pressure, single stroke, balance bob, pumping engine, is 33,000,000 pounds. It is stated, upon very good authority, that in one instance 125,000,000 pounds was pumped one foot high with a bushel of coals; when this great duty was performed it must be understood that a three hundred horse engine was being worked up to the power of a sixty horse engine only.*

Now it appears according to the above statement that 11,000,000 lbs. is saved by dispensing with the fly-wheel, and 92,000,000 chiefly by the expansive property of high steam.

There is, unquestionably, some allowance to be made for the second, third, and fifth reasons, perhaps 12 or 15 per cent. It would be extremely interesting and important to know to what extent this highly elastic single stroke expansive engine would apply to steam navigation. That it would be perfectly safe, is abundantly proved by the daily practice of steam gunnery, at the Adelaide Gallery. A saving of two-thirds of the weight and a like proportion in fuel, would probably be the result. Should these views be

* The advantage of this drawing off steam slowly from the boiler resulted, assuredly, from its not being allowed to get above the evaporating point, in any one part, which would undoubtedly have been the case, if it had been called upon to supply steam enough for a 300 horse engine. Recent experiments bear me out in this assertion, for by keeping the heated surface down to the evaporating point by rapid circulation, one foot of metal thus heated is of more value than many feet of metal heated above that point, varying in the ratio from 1 to 15, or more, according to the different degrees of temperature.

realized, then all parts of the world may be visited, by the aid of steam, with great economy.

I had not the least idea that any one, at the present day, was prepared to dispute the great advantage of using highly elastic steam expansively, or would venture to assert that it was not profitable, because to be so it must be permanently elastic, and must be supplied constantly with increments of heat to keep up the expansion.

By an experiment made some years since, and which was witnessed by two members of this Institution, and by a great number of other persons, I attempted to prove that no loss by condensation, in consequence of the sinking of the temperature, was perceptible, and all who witnessed it declared that the experiment was conclusive.* The following was the arrangement resorted to. I employed two single stroke cylinders, one eight times the area of the other, both standing on the same base, and both worked with the same crank. The steam was admitted into the small cylinder at its lower end, say at 600 lbs.† to the square inch; when the small piston had ascended one-quarter of the stroke the steam was stopped off, and when it had expanded four times, it was let on the upper side of the large piston, and it was found that the same amount of work was done by the descending stroke of the large piston as by the ascending stroke of the small one, showing that neither *permanently elastic steam nor fresh increments of heat were necessary.*

For the purpose of showing that the steam lost none of its power by expansion if properly applied to the fly-wheel and the steam blown off, when the small cylinder had finished its stroke, eight sixteen pound weights were put into the scale, which was attached to the long arm of the lever, and these did not stop the fly, but nine such weights did; the steam was now allowed to expand on the large piston and eight more sixteen pound weights were put into the scale, and the fly went off, as when the small cylinder only worked; seventeen weights, however, caused it to stop, showing, most satisfactorily, that no power was lost by expansion.

A. Holdsworth, Esq., one of the members alluded to, particularly expressed great pleasure at seeing this hitherto doubted property, so positively demonstrated; I mention Mr. Holdsworth in particular, because the other gentleman was of the new school.

To doubt the great increase of power obtained by expansion, after this experiment, the fact of its having been successfully made must be denied; the time is not far distant, however, when it will be of little consequence should a few determinately shut their eyes against such important truths.

Remarks upon the use of Pneumatic Engines, as applied to mines, and on their application to other purposes. By Jacob Perkins, Civil Engineer.

The Pneumatic engine which is the subject of these remarks, although it

* Although the cylinders were not clothed with a non-conductor, yet no perceptible loss was observed by condensation. The cylinders however were well polished and very thick, so that little heat radiated, probably not more than the extra heat which high steam possesses over low or atmospheric steam.

† The steam at 600 lbs. to the inch was let into the little cylinder at its lowest end, and stopped off at one-quarter of the upward stroke, and after expanding 36 times, it passed out of the cylinder below atmospheric pressure.

This high pressure single stroke double engine made 60 strokes per minute of course only one-half second is consumed between the strokes.

has been more or less used for a long time, has, from some cause, had its properties overlooked and neglected in a remarkable degree. This instrument certainly cannot be used as a prime mover, yet for distributing power it can be employed to great advantage. Some years since Mr. Hague obtained a patent for the application of it to the working of coal mines, &c., and the result has astonished all the engineers who have made themselves acquainted with the facts relating to it, which, to believe, they say, must have been seen. In one of these mines where the engines are performing the work, usually performed by horses, the most distant pneumatic engine is seven miles from the mouth of the shaft, where the prime mover, the steam engine, is at work; and the most distant pneumatic engine can be set at work as quickly, and as powerfully as any one of those which are intermediate, although some of them are but a short distance from the steam engine. The most extraordinary part of the operation is that of the air being exhausted simultaneously from each end of the main pipe, although seven miles distant from the air pumps. The complete ventilation of the mine is a very important result. The air which is used to work the pneumatic engine is the foul air of the mine, which is delivered at the surface of the exhausting pumps. But the most curious, and apparently paradoxical, feature of this engine is yet to be explained.

Having recently witnessed some of Mr. Hague's Pneumatic experiments I was powerfully struck with the amount of work the pneumatic engine performed, and which led me to study its operation. I had been acquainted with the fact that the sudden compression of air, by which its atoms are brought nearer together, caused a great increase of resistance by the repellant power of the heat thus generated, so that it required a pressure of much more than two atmospheres to force the air into one half its original bulk, and that after the air had been allowed time to part with this extra heat, it would then occupy but one-half of its original space. I then asked myself if so much power be lost by compressing the air and liberating the heat which it contained, why would not the expansion of the air take away resistance until the air had time to recover the heat and become of the same temperature as before it expanded. Now if there is a gain by the sudden exhaustion of heat, by the expanding of the air, thereby diminishing the resistance on the eduction side of the piston, we see a natural cause for what is said to take place as to the gain of power in the pneumatic, over the steam engine, which puts the pneumatic engine in motion. It is confidently stated that the pneumatic engines, at work in the mines, do much more duty than the steam engines working at their mouths.

To take advantage of this hitherto unobserved law, the pneumatic engine must be modified in such a manner as to allow the free access of the atmosphere, so that it may work on the induction side of the piston by its whole weight. In the present pneumatic engines the induction pipe is much too small, which causes the air to be more or less wire-drawn, so that the whole weight of the atmosphere cannot act with its full effect. This is the improvement which has grown out of having discovered this law, which has hitherto been unnoticed, and for which a patent is in progress. It is intended also to patent the application of the Pneumatic Engine to other useful purposes. For instance, it is proposed that an immense air vessel be laid under the surface of the earth, and that this magazine of power be laid as near to where the pneumatic engines are to be worked as may be most convenient. The air vessel may be exhausted by water power, by wind, or by steam. If steam is used as the prime mover, the proper place

for the steam engine would be at the coal mines, where the coals would cost comparatively nothing, since the transportation, as well as the duties, would be saved, and the culm, which with a properly constructed furnace would answer well to raise the steam, and of which vast quantities are lost, may be had for taking away. It matters not at what distance the prime mover should happen to be from the main air vessel, if the power should be used in great manufacturing towns, as the exhausting pipe would constitute a part of the air vessel. This principle applied to rail-roads, would be of the utmost consequence on account of the immense saving of wear and tear. All the present projected rail-roads and even as many more, may be worked by small stationary engines. These stationary pneumatic engines may be placed at convenient distances to set endless chains and ropes in motion at pleasure, according to circumstances. When these engines stop there is no power lost, as there is in the present locomotive and stationary steam engines by the waste steam blowing off; these, also, are always ready for action.

In some situations there are immense water falls running to waste, the power of which might be used also at any distance to exhaust the air vessel. There is at this moment a project on foot in Virginia, for working by water power, a rail-road three hundred miles in length; it so happens that a series of water-falls runs nearly parallel to the proposed rail-road, and a survey has been made by engineers; and although the cutting of a great number of canals from the different falls, to move the carriages by a series of water-wheels, at a great expense, has been recommended, a very favourable opinion has been entertained of the proposition. This new project will, however, very shortly be laid before those concerned. There are situations, such as waste lands, heaths, &c., where a forest of self-acting wind-mills might be placed to exhaust the air from extensive magazines, by which means an immense deposit of power may be accumulated, and used as occasion requires for working the pneumatic engines, rendering this uncertain and unsteady power available for many purposes. These wind-mills may be so constructed as always to face the wind, and so as to require no attention day or night; should the air pumps vary ever so much as to their speed, no injury would result.

Facts show that in adding heat to atmospheric air its power rapidly increases; if so, must it not be admitted that by extracting heat the power is rapidly diminished? What is the limit? May we not suppose that if all the heat were taken from the air, the atoms of air would settle into a liquid and a vacuum take place? The atoms of air being separated by heat, and by heat only, it follows that in the absence of heat a perfect contact of the atoms of the air must result, and perhaps a solid be formed. Steam deprived of a given portion of its heat liquifies, and if, of another given portion, it becomes solid, with an unknown quantity of heat still remaining, for philosophers have not been able to determine the natural zero. The operation of heat on water and on air is widely different. To obtain the pressure of an atmosphere by expanding air, it has only to expand to double its bulk; but to obtain the pressure of an atmosphere by the expansion of water it must increase its bulk nearly 1800 times; it takes but about double as much heat to expand water 1800 times, as it does to expand air twice. If adding heat to air increases its power so rapidly, why should not the subtraction of heat diminish its power in proportion? Now if advantage be taken of the extraction of heat by the sudden expan-

sion of air, which necessarily takes place on the eduction side of the piston of the pneumatic engine before it has time to regain the heat lost by expansion, by allowing the weight of the atmosphere to act with its full effect, it must be admitted more or less power is gained.

The amount of steam, or fuel, lost in working locomotive, as well as stationary engines, cannot be less than 50 per cent. The loss that takes place by coals burning to waste, whilst the engines are standing still, is not the only loss, for the motion of the locomotive shakes out and scatters its lighted fuel all along the road. There is much more heat lost from radiation, and from the motion of locomotive steam engines, than from stationary ones. The great importance of being able to dispense with the ponderous locomotive steam engine, from its being the principal cause of the destruction of rail-roads, in consequence of their great weights as well as the consequent friction on the rails, is perfectly apparent.

This system of applying pneumatic power is particularly applicable to uneven countries, for at an inclined plane the power may be so regulated that the speed need not be diminished for want of power.

The power of the falls of Niagara, which is now running to waste, might, should this system be found capable of adoption, be made available, and all that section of country, surrounding this mighty agent, might be supplied with a very cheap and convenient power for all manufacturing purposes as well as for rail-road traveling.

Process for Ink devoid of free acid. By R. Hare, M. D.

Writing Ink is usually constituted of the tanno-gallate of iron and a portion of sulphuric acid which had existed in the copperas, or sulphate of iron employed as one of its ingredients, the tanno-gallate being suspended and the acid dissolved in the water. This free acid is injurious to iron pens. Dr. Hare has observed that when an infusion of galls is kept over finery cinder till saturated, it forms a beautiful ink, in which of course there is no free acid.

This ink is rather more prone to precipitate than that made with sulphate of iron, and this propensity is not counteracted by the addition of gum arabic. But, on the other hand, it has the advantage of being easily suspended again by agitation, not forming any concrete matter insusceptible, like common ink grounds, of that distribution in water, which is necessary to good ink. The tanno-gallate of iron when obtained from a filtered infusion of galls and finery cinder, as above described, on being evaporated to the consistency of thick molasses, gum arabic in due proportion having been previously added, forms a pigment which might, it is conceived, supercede India ink. When completely dried it glistens like jet.

This tanno-gallate of iron only requires to be dried and ignited at a low red heat, in order to be converted into a pydrophorus. A few years ago Dr. Hare ascertained that, by a similar ignition in close vessels, cyano-ferrite of iron, the Prussian blue of commerce, gave a pyrophorus. But as the pure cyano-ferrite of iron, resulting from the addition of the ferro-prussiate of potash, more properly the cyano-ferrite of potassium, to a ferruginous solution did not form a pyrophorus; he was led to believe the presence of sulphate of alumine in the commercial Prussian blue was the source of the difference, probably by being converted into a sulphide of aluminium, or potassium.

The production of a pyrophorus from the tanno-gallate proves that iron and carbon, when in a state of minute division, are capable, by ignition in close vessels, of acquiring that property of spontaneous combustibility which entitles the body which possesses it, to be called a pyrophorus.

In truth these results are consistent with some facts mentioned by Berzelius, as having been ascertained by Mitcherlic, respecting the spontaneous combustibility of iron, reduced from the state of magnetic oxide to that of the pure metal in an extreme state of division. Also the spontaneous combustibility of the residue resulting from the ignition of the oxalate of iron at a red heat.

Rapid Congelation of Water by means of Hydric Ether and concentrated Sulphuric Acid, &c., by R. Hare, M. D.

In freezing water by the vaporization of Hydric, commonly called Sulphuric, Ether, there is much labour in pumping, and the etherial vapour condensing in the pump, disqualifies it for nice experiments until cleansed, Dr. Hare finds that the interposition of sulphuric acid lessens the requisite labour, and protects the pump. By means of a globe or bottle with two tubulure, and a glass funnel with a cock, the acid being in the globe, the water in a retort, and the ether in the funnel, while the two former are exhausted, on allowing the ether to descend upon the water, the congelation of this liquid is instantaneous.

It has been ascertained by the same chemist, that a permanent self-regulating reservoir of chlorine, may be made by means of the apparatus heretofore used by him for nitric oxide, substituting for the materials used in that case, manganese in lumps and concentrated muriatic acid.

In one case, Dr. Hare, doubting the purity of the gas, from some indications, among others the want of the usual degree of colour, in order to test it he exposed leaves of a thin metal called Dutch gold leaf, to a jet of this gas as he had previously done repeatedly, without any ill consequence; to his astonishment, an explosion took place, which burst the apparatus and produced a detonation as loud as if one of the explosive compounds of chlorine and oxygen had been generated. Yet the only agents employed were peroxide of manganese and chloro-hydric (muriatic) acid. It was the deficiency of intensity in the colour which led him to test it by means of the leaf metal. The colour of the protoxide is known to be of a deeper yellow than that of chlorine.

Physical Science.

On the Thermo-Electric Spark, &c. Communicated by C. Wheatstone, Esq., F. R. S., Professor of Experimental Philosophy in King's College, London.*

The following notice of some recent experiments made in Italy on the production of the thermo-electric current, will no doubt be acceptable to many of your readers. I shall confine myself to a simple statement and corroboration of the facts, avoiding all theoretical considerations.

The Cav. Antinori, Director of the museum at Florence, having heard that Prof. Linari, of the University of Siena, had succeeded in obtaining the electric spark from the Torpedo by means of an electro-dynamic helix

* Communicated to this Journal by Prof. A. D. Bache.

and a temporary magnet, conceived that a spark might be obtained by applying the same means to the thermo-electric pile. Appealing to experiment his anticipations were fully realized. No account of the original investigations of Antinori has yet reached this country, but Prof. Linari, to whom he early communicated the results he had obtained, immediately repeated them and published the following additional observations of his own in *L'Indicatore Sanese*, No. 50 of December 13th, 1836.

1st. With an apparatus, consisting of temporary magnets and an electro-dynamic spiral, the wire of which was 505 feet in length, he obtained a brilliant spark from a thermo-electric pile of Nobili's construction, consisting only of twenty-five elements, which was also observable in open daylight.

2d. With a wire eight feet long coiled into a simple helix, the spark constantly appeared in the dark, on breaking contact at every interruption of the current; with a wire fifteen inches long, he saw it seldom, but distinctly; and with a double pile even when the wire was only eight inches long. In all the above mentioned cases the spark was observed only on breaking contact, however much the length of the wire was diminished.

3d. The pile consisting merely of these few elements, and within such restricted limits of temperature as those of ice and boiling water, readily decomposed water. Short wires were employed, having oxidizable extremities; the hydrogen was sensibly evolved at one of the poles.

4th. A mixture of marine salt moistened with water, and of nitrate of silver, being placed between two small horizontal plates of gold communicating respectively with the wires of the pile, the latter after having acted on the mixture, gave evident signs of the appearance of revivified silver on the plate which was next the antimony.

5th. An unmagnetic needle placed within a close helix formed by the wire of the circuit, became well magnetized by the current.

6th. Under the action of the same current the phenomenon of the palpitation of mercury was distinctly observed.

The interesting nature of these experiments induced me to attempt to verify the principal results. The thermo-electric pile, I employed, consisted of 33 elements of bismuth and antimony formed into a cylindrical bundle $\frac{3}{4}$ of an inch in diameter, and $1\frac{1}{2}$ in length. The poles of this pile were connected by means of two thick wires with a spiral of copper ribbon fifty feet in length and one and a half inch broad, the coils being well insulated by brown paper and silk. One face of the pile was heated by means of a red hot iron brought within a short distance of it, and the other face was kept cool by contact with ice. Two stout wires formed the communication between the poles of the pile and the spiral, and the contact was broken, when required, in a mercury cup between one extremity of the spiral, and one of these wires. Whenever contact was thus broken a small, but distinct, spark was seen. Professors Daniell, Henry, and Bache assisted in the experiments and were all equally satisfied of the reality of the appearance.

At another trial the spark was obtained from the same spiral connected with a small pile of 50 elements, on which occasion Dr. Faraday and Professor Johnson were present, and verified the fact. On connecting two such piles together so that similar poles of each were connected with the same wire, the same was seen still brighter.*

I conclude, therefore, that the experiment of Antinori is a real addition

* The two piles here employed were made by Mr. Newman, of Regent street.

to our knowledge of electrical phenomena, and though it was far from being unexpected, it supplies a link that was wanting in the chain of the experimental evidence which tends to prove that electricity, from sources however varied, is similar in its nature and in its effects; a conclusion rendered more than probable by the recent discoveries of Faraday. The effects thus obtained from the electric current originating in the thermo-electric pile, may no doubt be easily exalted by those who have the requisite apparatus at their disposal. It is not too much to expect, seeing the effects already produced by a pile of such small dimension, that by proper combinations the effect may be exalted to equal those of an ordinary voltaic pile.

I shall conlude this hasty communication with a notice of some experiments on the chemical action of the thermo-electric pile made earlier by Prof. G. D. Botto, of the University of Turin; the form of the pile he employed may suggest some useful hints to those who are inclined to continue the inquiry, as it admits of the application of much higher degrees of heat than one of the ordinary construction does, though the difference of the thermo-electric relation of the two metals employed is not so considerable. Prof. Botto's experiments were published in the Bibliotheque Universelle, for September, 1832, and I am not aware that they have yet been noticed in any English journal. The thermo-electric apparatus was a metallic wire or chain, consisting of 120 pieces of platina wire each one inch in length, and one-hundredth of an inch in diameter, alternating with the same number of pieces of soft iron wire of the same dimensions. This wire was coiled as a helix round a wooden rule eighteen inches long, in such a manner that the joints were placed alternately at each side of the ruler, being removed from the wood at one side to the distance of four lines. Employing a spirit lamp of the same length as the helix, and one of Nobili's galvanometers, a very energetic current was shown to exist; acidulated water was decomposed, and the decomposition was much more abundant, when copper instead of platina poles were used, in this case hydrogen only was liberated. The current and decomposition were augmented when the joints were heated more highly. Better effects were obtained with a pile of bismuth and antimony, consisting of 140 elements bound together into a parallelopiped, having for its base a square of two inches, three lines, and an inch in height.

King's College, April 24th, 1837.

Synthesis of Ammonia by means of Nitric Oxide and Hydrogen. By R. Hare, M. D. *Professor of Chemistry, in the University of Pennsylvania.*

Understanding that the synthesis of ammonia had been effected by the reaction between nitric oxide and hydrogen promoted by the presence of platina sponge, Dr. Hare, having no knowledge of the process as performed in Europe, succeeded in the following manner in the attainment of that highly interesting result.

Two volumes of nitric oxide and five of hydrogen, were introduced into a bell glass with a perforated neck furnished with a cap and cock. At the bottom of a tubulated glass retort, capable of holding about four ounce measures of water, a small heap of platina sponge was made. A leaden pipe communicating with the cock of the bell at one end, and at the other terminating in a copper or glass tube, having a bore about as large as a knitting needle, was passed through the tubulure so that the orifice of the

tube was nearly in contact with the metallic heap. The pipe was made to form an air-tight juncture where it entered the tubulure, and the beak of the retort was recurved so as to be beneath the surface of some water in a wine-glass. The bell being depressed below the surface of the water in the pneumatic cistern, the cock was opened so as to allow the gaseous mixture to enter the retort and displace the atmospheric air. As soon as this was known to have taken place, by the disappearance of the red fumes, resulting from the reaction of the nitric oxide and atmospheric oxygen, the gas being still allowed to pass slowly in bubbles through the water in the wine glass, an incandescent coal was held near the part of the retort supporting the sponge. The metal being thus heated became ignited, and fumes appeared in the cavity of the retort. An absorption of the water in the wine glass followed, which was however immediately checked by a supply of gas from the bell sufficient to cause the bubbling to recommence and continue. Under these circumstances the water in the wine glass acquired the odour of ammonia, and gave with copper the well known blue colour.

In a subsequent experiment a small lump of the sponge was secured in a coil of platina wire and fastened to the tube so as to receive the jet of the mixed gases.

Dr. Hare published the fact, some years since, that asbestos soaked in a solution of chloride of platinum and ignited, would cause the inflammation of hydrogen with oxygen. He finds asbestos, similarly prepared, to produce the synthesis of ammonia, either when substituted for the sponge, in the experiment above described, or carried red hot from a fire and passed into a bell glass containing the mixture over mercury.

In fact a piece of charcoal soaked in a solution of chloride of platinum, (choroplatinic acid,) produced effects analogous to the platinated asbestos.

To produce platinated asbestos, it was found sufficient to dip it in liquid chloride of platinum, and then subject the mass to a red heat in a common fire.

Rotory Multiplier, by R. Hare, M. D.

Dr. Hare has contrived a Rotory Multiplier in the following way:

Just as the needle, in oscillating, reaches its appropriate position in the meridian, by means of two pins proceeding from it perpendicularly so as to enter two mercurial globules, it completes a circuit through the coil; one end of which terminates in one of the globules. The other end of the coil of the multiplier communicates with one pole of a galvanic pair, of which the other pole communicates with the other globule. The needle is thus subjected to an impulse which causes it to revolve until it receives another impulse by the same process repeated. Each revolution therefore causes an impulse which is productive of a succeding revolution so long as the galvanic reaction is sustained.

The construction was subsequently improved by employing two coils of copper wire of equal length, separated by paper, and varnish, one being wound over the other. They were so arranged that the needle receives two impulses in each revolution, one as above described, the other when its north pole points to the south. Again two needles associated so as to form a cross are made to complete a circuit every fourth of a revolution, and thus to receive four impulses in one revolution. The completion of the circuit is effected by pins of copper, which descend vertically from the needle and enter globules of mercury, communicating generally with the ends of the

coils and the poles of a galvanic pair duly excited. The instruments were exhibited in operation by Dr. Hare, at the Conversation Meeting of the Franklin Institute, in April.

It has been ascertained by the same chemist that a permanent self-regulating reservoir of chlorine may be made by means of the apparatus heretofore used by him for nitric oxide, substituting for the materials, in that case used, manganese in lumps and concentrated muriatic acid.

In one case Dr. Hare doubting the nature of the gas, in order to test it, exposed some leaves of thin metal, called Dutch gold leaf, to a jet of the gas. To his astonishment the whole apparatus exploded violently as if one of the explosive compounds of chlorine and oxygen had been generated.

This result is quite inexplicable to Dr. Hare, especially as the paleness of the hue led him to doubt the purity of the gas. The oxides of chlorine are well known to be deeper in colour than their radical, when isolated.

Experiments on Solar Light. By John W. Draper, M. D. Professor of Chemistry, Hampden Sidney College, Va.

1, *Action of absorbent media.* 6, *absorption of the different rays of light and distorted spectra.* 16, *absorption of radiant heat, instrumental arrangement for measuring.* 24, *action of vapour of iodine and nitrous acid.* 28, *absorption of chemical rays.* 29, *bodies nearly opaque to them.* 33, *thermal disturbance of gaseous mixture, and penetration of their dimensions.* 38, *decomposition of carbonic acid by the Sun's light.* 39, *by radiant heat.* 40 *power of capillary action exalted by heat.*

1. The effect of absorbent media upon the colorific rays of light, has been, as was predicted by an eminent writer on Optics, of singular service in developing new views of this subtle agent, and giving us a more precise knowledge of the complex constitution of the Solar beam. Hitherto, the action of these media, upon the calorific and chemical rays, has not been thoroughly investigated, nor are there, so far as I know, any experiments on record, exhibiting this matter in its full importance.

2. We have been accustomed to regard the chemical properties of the Solar ray spectrum, as due to the violet ray,—as something coherent to it. A similar opinion was formerly maintained, respecting the calorific constition of the red ray. The position to which we are brought by advanced investigation, has long ago established the separate existence of heat making rays, and the experiments here communicated give much weight to the doctrine, that the chemical rays have also a separate existence. It is true it cannot yet be proved, though analogy and probability are favourable to the idea, that there are sub-divisions both of the chemical and calorific rays, similar to those of which our senses give evidence in the colorific ray, each of which is endued with distinct powers of its own.

3. How complex and compounded is the constitution of the solar beam; a ray of heat, composed perhaps of three or more rays of different refrangibility; a ray of light, composed of three simpler rays; a ray endued with chemical energy, and of a similar composition to the former, as analogy would lead us to suspect. Again, each of these elementary rays is composed of particles, one-half of which have their planes of polarization at right angles to the other. All these elements taken together, constitute a beam of the same light. Emanations from the sun, after they have undergone the absorptive action of the atmosphere of that great luminary, and of that

of the earth, still reach us in abundance, accompanying his light, and traversing the great vacuum, perhaps as far as his attraction is felt.

4. If we take a coloured medium, of any kind, and transmit through it a beam of the sun's light, we find, on examination, that certain of the rays exciting vision are absorbed, that the light which passes through is not homogeneous, for it is capable of decomposition by the prism; it is a compound coloured ray, consisting of all the rays, complementary to those which the medium has absorbed. Nor is this absorbing effect confined to the rays producing vision, the rays of heat suffer in like manner, sometimes those which are more refrangible are wanting, sometimes those which are of less, or of medium refrangibility are absent. Often, at the same time, do the chemical rays sustain a similar attack. There are solutions and media, transparent to light and nearly opaque to heat; there are others, transparent to light and to heat, and opaque to the chemical ray. It is from these facts, that we are able to establish the separate existence of three genera of rays, in the sunbeam, each of which is essentially distinct in its properties, and different in its mode of action, to the others. Our eye can detect, in the rays exciting vision, difference of constitution, because we are able to perceive a difference of colour. Had we specific organs for indicating difference in the heat making, or chemical, rays, perhaps we might find in them a similar constitution.

5. It is between three and four years since, that the investigation, which forms the subject of these papers, was first commenced, under the form of an examination of the properties of the chemical ray. In two of the numbers of the Journal of the Franklin Institute, V. XV, p. 79, and p. 155, some of the earlier results are recorded, and among them the extraordinary fact, that the crystallization of camphor, which has long been known to take place on the enlightened sides of vessels exposed to the sun, occurs with very great rapidity, if the glass in which it is tried, be exhausted of air. In tracing out this fact, to ascertain its cause, a field of abundant discovery, and, no common interest, has been entered. I do not here present a record of the facts as they were successively developed by an analysis of the phenomena; but place them in that order which appears to me the best to obtain a true estimate of their bearing.

6. Into a darkened chamber, the shutter of which is seen in section at *a a* Fig. 1. Plate XI. a beam of the sun's light may be made to pass horizontally, by means of a mirror of silvered glass *c*. The mirror which I use is one belonging to a solar microscope, and by turning the milled screws *e e*, it can be brought into any position required to throw a beam horizontally into the room, no matter what may be the place of the sun. A brass tube *f*, belonging to the same instrument, and two inches in diameter, can be screwed into the position figured, if desirable; there is also a lens, *g*, which may occasionally be fixed at *g*, its focus is nine inches, its diameter about two inches, and the diameter of the Sun's image $\frac{1}{10}$ of an inch.

7. A piece of sheet lead about a quarter of an inch thick, is to be cut into the form of a horse-shoe, of such magnitude that a circle one inch diameter might be inscribed in it. Upon this lead, two pieces of very pure and transparent crown glass are cemented, so as to form a trough, for containing a variety of liquids. It is well to accommodate this trough with a strong foot, or basis *a a*, and several such troughs may be provided. Fig. 2, *c c c* the leaden horse-shoe, *b b* the glass plates.

8. A thin metallic plate, three or four inches square, is also to be pro-

vided, having a longitudinal slit about one inch long, and $\frac{1}{15}$ inch wide, in it. It is convenient that this, too, should be furnished with a pediment, Fig. 3, *a a* the slit.

9. The lens *g*, Fig. 1. having been removed; by turning the screws, a beam of light is to be thrown horizontally into the room, the screen Fig. 3 is then to be placed before the brass tube *f*, so that the slit in it may allow a narrow streak of light to pass. The trough Fig. 2 is then placed behind, in such a position that half the light which comes through the slit in the screen, may pass through the liquid contained in the trough, and the other half pass by its side unintercepted. This arrangement is shewn in Fig. 8. Behind the trough is placed a flint glass prism *a*, Fig. 4, and further still a white pasteboard screen *e*, of suitable dimensions, *a* being the screen, *b* the trough.

10. The action of this arrangement is as follows. The beam of light cast by the mirror into the room, is entirely intercepted, except the small portion which passed through the slit, in the metallic screen. A part of this passes through the trough, and a part on one side of it, the middle part being obstructed by the leaden horse-shoe. Two beams of light, therefore, fall on the prism, one of which has passed through the trough, and one which has not, and they are separated from each other by a dark interval. The prism decomposes both, and there falls on the pasteboard screen, two spectra side by side, and close enough for a very accurate examination. One of them has been acted on by the fluid in the trough, the other is undisturbed. In my arrangement the spectrum *a* happens to be the natural one, and *b* the disturbed one, Fig. 10.

11. Let us now take an example, as an illustration of the use of this apparatus. Fill the trough with distilled water, and let the mirror throw a horizontal beam. Two spectra are seen on the screen *e*, Fig. 6, close to each other, side by side, with a dark interval between them. They contain, as may be perceived, all the seven colours of Newton, nor does the one differ in any wise from the other as in Fig. 11.

12. Having poured the water out of the trough, fill it with a strong, but clear, solution of the chromate of potassa; on looking at the spectra on the screen, *a* is still found of its natural appearance, but by the side of it there is a distorted spectrum, formed by the light that has passed through the trough; the blue, the indigo, and the violet rays, are wanting, as is seen in Fig. 12, these colours have then been absorbed, by the solution of chromate of potassa. If this solution be poured out, and one of sulphate of copper and ammonia poured into the trough, another kind of spectrum is produced, where the red, and much of the yellow light, is wanting, see Fig. 13. If a strong solution of brazil wood is used, the disturbed spectrum will be found to have lost its violet, indigo, blue, green, yellow, and a great part of its orange rays, as represented in Fig. 14.

13. By having the two spectra side by side, and close to one another, they are placed under circumstances most convenient for making a perfect comparative estimate of the light which is lost. In this manner the following table has been constructed. The specific gravity of the solutions is not given, as it is not supposed that any direct connexion exists between the density of a solution and its absorptive power. Much more depends on the shade of colour.

Table of Colorific Rays absorbed by solutions.

Name.	Rays absorbed.
Bichromate of potassa,	blue, violet.
Prussiate of potassa,	extreme red, extreme violet, yellow.
Sulphate of copper,	extreme red.
Chloride of gold,	violet.
Chloride of platinum,	extreme violet.
Sulp. copper and ammonia,	red, yellow.
Solution of tannin,	violet, indigo blue, orange and a part of green.
Solution of Litmus,	orange, yellow, green, extreme violet.
Chromate of potassa,	extreme red, blue, violet.
Linseed oil,	violet, indigo blue.
Hydro-sulphate of lime,	violet, blue.
Decoc. logwood in alum water,	orange, yellow, blue, and green.
Decoc. of brazil wood,	violet, indigo blue, green, yellow, orange.
Cochineal in cream of tartar solution,	yellow and part blue.

14. Some remarkable phenomena may be produced, by taking double solutions; a beam which has passed through a stratum of solution of sulphate of copper and ammonia, and then through a decoction of brazil wood, becomes almost totally extinct. On looking through such solutions, separately, at the noontide Sun, he appears with overpowering effulgence, but on using them together, only a very faint trace of a dirty olive green light, indicates his position. The sulphate of copper and ammonia, absorbs the red rays, and the Brazil wood decoction, nearly all the remainder.

15. Already have some of these phenomena of absorption, in the hands of Sir D. Brewster, disclosed important facts respecting the colorific rays. The colour of the sky, and of the clouds, and of the sea has also been long attributed to an action of this kind, exercised by thick masses of air, or vapour, or water.

16. But this action is not alone confined to the rays producing vision, it extends to the other elementary constituents of the spectrum. Whilst the trough *b* Fig. 4, is filled with a solution of sulphate of copper and ammonia, if the prism and the metallic screws be removed, and a very delicate thermometer be plunged in the ray, a new phenomenon is discovered; the ray is found to be, to a great extent, deprived of the power of exciting heat, and the thermometer shows little disposition to rise. How is this? is it because the red making ray is gone, that the sunbeam has lost its power of exciting a sensation of warmth? It was at one time supposed, that as the violet ray had the power of determining chemical change, so the red ray possessed the power of exciting calorific impressions.

17. Fill the trough next with a strong decoction of Brazil wood, analyse the light which passes through it, by the prism, (sect. 9) and it will be found that all the rays have been absorbed except the red. Now, in such a beam, if the red ray possess inherent caloric, the thermometer should rise as much, or nearly as much, as if it were in the direct solar ray; if the colour passes in all its integrity, so too should the caloric; but place the thermometer in the beam, and it does not rise. Nay, throw a concentrated column of such light upon it, by a convex lens, and it is still unmoved. We are therefore forced to conclude, that the rays exciting heat, are independent of those exciting vision; that neither the red nor the yellow, nor the blue, possesses inherent caloric; and moreover, that substances may be transparent

to red, to yellow, or to blue light, or to all, and yet more or less opaque to the rays of heat.

18. It is not alone among watery solutions, or alcoholic tinctures, that we find abundant instances of this kind of action, the mineral kingdom furnishes many. A very thin lamina of pitch, is transparent to red light, but almost opaque to the rays of heat. I have examined a variety of bodies, gaseous, liquid and solid, and shall here point out the method which has been followed in obtaining the results contained in the following table.

19. The mirror being placed upon the shutter as in sect. 6, a plano-convex lens is to be screwed into the tube, so as to bring the rays to a focus, on one of the balls of a very delicate differential thermometer, the motion of the fluid is rapid, and the instrument soon attains a position of equilibrium: this gives the heat of the sunbeam as concentrated by the lens. To find the effect of any liquid medium in absorbing these rays, the trough filled with the substance under trial, is placed at the extremity of the brass tube, in a position as at *c* Fig. 5. The cone of rays converging from the lens *a*, on the ball *b*, is subjected to its action, but because the trough has plain and parallel surfaces, the rays still pass on, and form an image on the focal ball of the thermometer. The total effect, as given by the expansion of the gas in the instrument, and which has formed the basis of the following table, is not however an exact estimate of the action of the liquid solution. In the instrument which I am in the habit of using, the convex lens is of flint glass, and the plates of the trough of Boston crown glass; there are therefore at least two disturbances, the absorbing action of the former, and still more powerful effect of the latter. It has been considered, from the experiments of *Melloni*, that the power of absorption, was inversely as the power of refraction, but whether an extended train of investigations, will corroborate this supposition, remains to be seen. In the following experiments, the instrumental arrangement being always identical, a comparison may be instituted of the action of any two of the solutions; but the absolute action of each cannot be determined, except after allowing for the additional effect of the flint glass lens, and the crown glass plates.

In the practical operations, it will be found very useful, to blacken the focal ball of the thermometer, as seen at *e* Fig. 5, which serves to give a larger scale of thermometric expansion. It is also requsite to cover the thermometer, with a very thin case of pure and transparent glass, which serves not only to prevent the disturbance of currents, but also, of the heat radiated from other bodies in the vicinity; this introduces however the absorptive action of a third plate of glass; *b d* is the thermometer, and *e e* the glass cover, Fig. 5.

21. By these arrangements it was found that a thin stratum of pitch enclosed between two plates of crown glass, and which transmitted a homogeneous red light, absorbing all the other colours of the spectrum, allowed only nineteen rays of heat to pass through it, of every hundred that fell upon it.

22. A solution of the sulphate of copper and ammonia that absorbs the red and the yellow light, being operated upon in like manner, was found to transmit twenty rays, for every hundred that fell upon it.

23. There is however considerable difficulty in obtaining these numerical results with accuracy, arising partly from the difficulty of obtaining specimens of exactly the same composition, but more especially, owing to changes taking place in their colour. In process of time, most vegetable solutions undergo spontaneous changes, and no longer give the same results.

But, where the same sample is operated on, under the same circumstances, repeated experiment assures me, that this arrangement gives comparable indications.

24. Vapours and gases, may also be put under trial. The vapour of iodine, whose spectrum is remarkable as containing only the extreme rays, and wanting those of medium refrangibility, Fig. 15, absorbs two-thirds of the heat that impinges on it. The vapour of nitrous acid, which stops the violet, blue, indigo, and yellow light, Fig. 16, has a similar effect on the heat. To experiment upon these bodies, a cubical bottle, Fig. 17, is very convenient to generate the vapour in, and also to transmit the light through; it will then replace the trough of section 7. Nitrous acid vapour is best made for these purposes from Nitrate of Lead.

25. Having prepared a variety of solutions for the purpose of experiment, and using for each the same trough, thoroughly cleansed after each trial, the following table will give an estimate of the results obtained, it is arranged according to the power of each solution, the first on the list being the most energetic.

Table of the Thermo-absorptive power of Solutions.

Decoction of logwood in alum water	Muriate of cobalt,
Solution sulph. copper and ammonia,	Bichromate of potassa,
Litmus water,	Hydro-sulphate of lime,
Decoction Brazil wood,	Muriate of iron,
Decoction cochineal,	Oil of turpentine,
Solution tannin,	Prussiate of potassa,
Solution chloride chromium,	Sulphate of copper,
Tincture turmeric,	Chloride of platinum,
Tincture saffron,	Chloride of gold,
Ink diluted,	Oil of bergamot,
Sulphocyanate of iron,	Linseed oil,
Hydro-sulphate ammonia.	Nitrous ether,
	Water.

26. Still more powerful effects are produced, by making binary or ternary arrangements. If, for instance, a beam of the Sun falls upon a very thin transparent stratum of pitch, and then passes through a solution of sulphate of copper and ammonia, or through linseed oil, not more than one-fortieth part of the caloric is transmitted.

27. A question here naturally arises, what becomes of the heat thus lost; does it enter into such combination with these media, so as to be detected in them by the thermometer, as sensible heat? One of the pupils of this school, Mr. Good, examined the amount of sensible heat, which these solutions acquire on being exposed to the solar ray. It is a question of much difficulty, there are so many disturbing causes in operation, the general results of such experiments have not yet furnished actual proof, that the heat missing is to be found in the fluid solutions. I would not however be understood to deny that such is the case, only, that at present, our information does not warrant such a conclusion. It might be supposed that these solutions do not act by a proper absorptive power, but merely offer that kind of obstacle to the transmission of heat that *turbid* media do to light. Not only, however, does direct experiment discountenance this, but the analogy of their action on the chemical ray, renders it extremely improbable, an action which I proceed to develop, Fig 5 being still consulted.

28. Having removed the differential thermometer and its case, and produced a cone of light converging from the lens, where light passes through a solution of sulphate of copper and ammonia, contained in the trough; if now, we hold in the focus a piece of bibulous paper, imbued with chloride of silver, although little or no heat is transmitted through the solution, yet an extremely dark spot is produced, characteristic of the blackening of that substance, by the solar rays. Though, therefore, the double salt transmits the ray of heat with difficulty, the ray of chemical action passes with great facility. If a trough, containing a strong solution of bichromate of potassa, be now substituted, a far larger quantity of light will pass, and vastly more heat, but a paper imbued with chloride of silver, being held in the focus, *no chemical change whatever goes on*, the chloride retaining its usual whiteness.

29. I placed a piece of paper, imbued with chloride of silver, in a cubical box, one of whose sides was formed of a pair of glass plates, with a solution of bichromate of potassa between them; it was exposed for many days to the sun's light, and only assumed a faint bluish stain, whilst a similar piece exposed to the direct rays, was fully blackened in fifteen minutes. So powerful is the action of this salt, that when a stratum of it, not more than the hundredth part of an inch thick, was included between two plate glasses, it stopped the decomposition of chloride of silver. It was after a long examination of a great variety of substances, that I first became acquainted with the great absorptive power of the chromates of potassa. In my earlier experiments, I had made use of the chloride of platinium and the chloride of gold, both of which have an analogous action. The solutions, which I have recognised as possessing this power in the most eminent degree, are

Bichromate of potassa.
Chromate of potassa.
Yellow hydro-sulphuret of ammonia.
Hydro-sulphate of lime.
Muriate of iron.
Chloride of gold.
Chloride of platinum.
Coloured vegetable solutions.

It is remarkable that all the *mineral* solutions, on this list are *yellow*; the absorptive power however is by no means connected with that colour, for the yellow tint is a compound one; all the rays of homogeneous light, are absorbed by one or other of the bodies, on the foregoing list.

30. It is interesting to know whether these absorptions be really the abstraction of something from the Solar ray, or merely some change impressed upon it. If light consisted merely of tremblings, pulses, or undulations, or any other kind of motion of a homogeneous elastic medium, in virtue of which it is competent to excite sensations of heat, and effect chemical change, we might explain the action of these media, as the result of some change occurring to that motion, either in direction or degree. We might suppose too that when a ray had been deprived of its power, by passage through one medium, it might have it restored, in a greater or lesser degree, by being transmitted through another. I have not found, in thus comparing together nearly three hundred media, any indications of such a result; and therefore suppose, that something of a material character has been abstracted from the ray, that it is really a loss, and not a change.

31. Being thus possessed of the means of depriving the beams of the sun

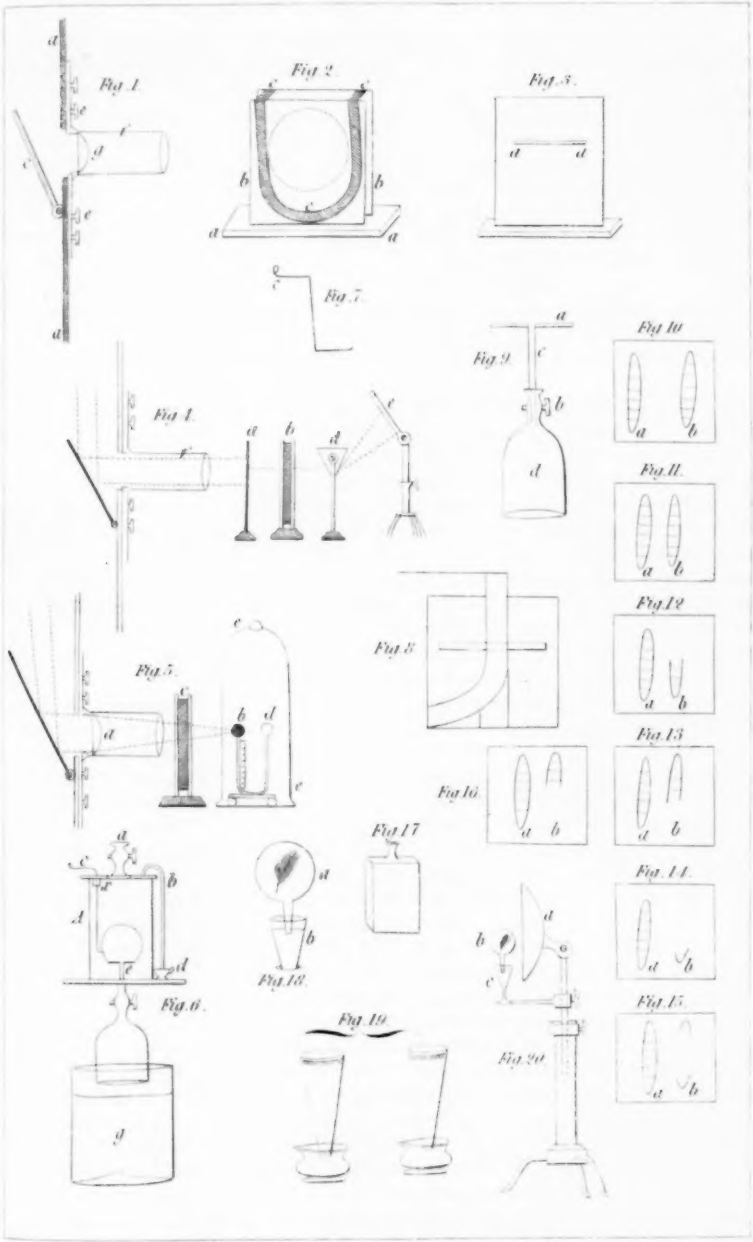
of their heat and their chemical force, I have proceeded to examine a variety of questions of interest. A great many changes in the constitution of bodies, on their exposure to light, are recorded in the books of chemistry and physics, but they are there imputed to light, *in the aggregate*, without any reference to its compound character, we shall find there are changes due to the colorific ray, changes due to the calorific ray, and changes due to the chemical ray.

32. One of the most important and extensive functions exercised by radiant matter from the sun, is the decomposition of carbonic acid by vegetable leaves, and the elimination of oxygen gas. Vegetable physiology looks to chemistry for information, but hitherto the chemist has not possessed the means of perfectly developing the matter, and unfolding its mystery. Its intrinsic importance entitling it to investigation, I shall not offer any apology, for passing from the direct object of this paper, to the mention of some facts, necessary to the thorough understanding of the matter.

33. It would appear, that there is a particular kind of combination to which attention has hardly yet been drawn, distinct from what are understood by chemical combination and mechanical mixture. A pint of alcohol, and a pint of water, being mixed together, the result will measure somewhat less than a quart, and the same might be indicated, of a variety of other liquids. No instance I believe is yet on record, of a like penetration of dimensions, being observed in the case of gases; if it exist at all, it exists to a very small amount, and the change of volume which these bodies readily experience, by alteration of temperature and pressure, renders so minute an effect, very difficult of detection. It has been supposed, judging from analogy, that the constituent gases of the atmosphere, the uniting volume of which is always constant, are held together in this manner, or that the whole volume is condensed and retained by some force of compression. There are some experiments which indirectly prove this: sound passes along different media with a different velocity; if a cannon were therefore discharged at a distance, it should impress the ear with two distinct sounds; the one coming along the particles of nitrogen, should arrive first, and shortly after be followed by one passing along the oxygen, the intensity of these sounds, not being the same, on account of the superior density of the nitrogen; that is, if the particles of oxygen and nitrogen transmitted sounds independent of one another, or in other words if they were not in a state of condensation, the molecules of the one pressing on the molecules of the other. But it is well known, from observations made directly on this point, that instead of there being any reduplication of the sound, it comes clear, distinct and alone,—we have therefore to infer, that these two gases are held together in a state of compression.

34. In making experimental investigations of this matter, two different courses may be followed; first, we may measure the resulting volume, after the mixture of known volumes of the gases under trial; or, secondly, we may ascertain whether any thermal disturbance takes place, during the act of their uniting, the latter is the mode I have followed in my researches.

35. Take a cylindrical glass, A Fig. 6, Plate XI. two inches in diameter, and four in height, close its upper extremity with a flat piece of wood, by means of cement, in the centre of it cement a stop cock *a* of large bore, and at a suitable distance from that centre, make two holes the one to have a piece of bent tube *b*, cemented into it to serve as a gauge, the other to have a piece of copper wire *c* bent into the shape *c* Fig. 7, passed through it air tight, by means of a cork *x* imbued with tallow. The other extremity of



Experiments on Solar Light.

the cylindrical glass, is likewise to be closed by a flat piece of wood, larger than the former, for the purpose of bearing a little cup *d*, containing coloured water, into which the gauge tube may dip, and in its centre it is to be perforated to admit of an arrangement as in Fig. 9, Plate XI. where *d* is a perforated cupping glass, having a stop-cock *b* mounted on it, whose further extremity opens into a glass pipe *c*, which terminates in a hole, in the centre of a flat copper circle *a*, three-quarters of an inch in diameter, this arrangement is to be cemented, air-tight, into the flat piece of wood, that closes the lower extremity of the cylindrical glass, as is seen in Fig. 6. Moreover, beneath the cupping glass, there is a glass reservoir *g*, of suitable dimensions, filled with water. The object of this arrangement, is to fill a soap bubble with any gas, to expose it to atmospheric air, to burst it at will, and to mark any thermal expansion of the two gases, by the indications of the gauge; the mode in which this is accomplished, will be described in the following illustration.

36. The whole apparatus having stood for some time in a quiet room, along with the gases to be tried, until they have all acquired an uniform temperature, close the lower cock, fill the cupping glass with hydrogen gas, and raise the reservoir *g*, so that the level of the water may be near the top of the cupping glass. The upper cock being open, convey through its bore, by means of a glass tube, of smaller diameter, a little soap water, which is to be deposited on the copper circle, in its centre, over where the glass pipe *c* opens, the tube is then withdrawn. Next open slowly the lower cock, and as the gas is expelled from the cupping glass, by the pressure of the water in the reservoir, it expands a bubble in the large cylinder, the displaced atmospheric air, passing out through the upper cock. When this bubble has attained the dimensions desired, close both cocks, and observe if the liquid in the gauge be stationary; if so, turn the wire *c* on its axis, so as to bring its crooked extremity, which is within the cylinder, in contact with the bubble; it bursts, there is a thermal disturbance, and an expansion of the two gases, for the fluid in the gauge instantly falls, and as the gases cool, it slowly returns to its former position. If a bubble of atmospheric air be employed, instead of a bubble of hydrogen, these effects will not ensue. We therefore conclude, that when hydrogen gas is mixed with atmospheric air, the temperature suddenly rises, and therefore that it is probable, that the volume of the mixture, is *less* than the sum of the volume of its integrant constituents.

37. If a soap bubble, filled with hydrogen, be burst in an atmosphere of nitrogen gas, which may be effected by using a more complex arrangement, than that indicated in the preceding section, there is also a thermal expansion, indicating that the constituents of ammoniacal gas, even without chemically uniting with one another, exercise an attraction for, or a pressure on, each other, a kind of capillary action. These compounds, for they form a distinct class of bodies, a class by no means of small extent, require a distinct name. I have suggested that of capillary compounds; because they exist under, and can be decomposed by the force of capillary attraction. An example will here illustrate what is meant. Oxygen and hydrogen gases may be mingled with each other in the proportion of one to two, the result existing in a compressed state, and forming a capillary compound; the contact of flame, or the passage of an electric spark, changes it into aqueous gas, a chemical compound; in the former state, decomposition is readily effected by capillary attraction; in the latter it cannot produce such a result. The general law of these decompositions by tissues without

pores of sensible size, was announced by me in the Journal of the Franklin Institute, Vol. XVII p. 1, &c., it is a very simple one, showing that a capillary equilibrium is gained, only when the composition of gaseous media on each side of a barrier, is chemically the same. This was proved by exposing extremely thin soap bubbles filled with different gases, to different gaseous atmospheres, and then measuring and analysing the media, within the bubble and without. This law is applicable not only where a barrier separates a gas from a gas, but also when one of the gases is held in solution by water; and in the energy with which the media endeavour to attain an equilibrium, is to be found not only one of the causes of the decomposition of carbonic acid by the light of the Sun, but also a very fruitful source of erroneous experimenting. Having made reference to this matter, I proceed to detail the steps which have been taken, to lay bare the mystery of this decomposition.

38. Take four globular vessels, such as *a*, Fig. 18, Plate XI. three or four inches in diameter, with necks a couple of inches long; fill them with spring water, and put a bunch of pine leaves in it, immerse the end of the neck beneath the surface of the mercury, contained in a cup *b*. Let one of these vessels designated A, be exposed to the sun's direct ray; a second B, to the light which has passed through a solution of bichromate of potassa; a third C, to the light which has passed through a solution of sulphate of copper and ammonia; and a fourth D, in a dark place. It will be found that in the course of a few hours, A has eliminated most gas, B somewhat less, and C and D none at all; this is a very instructive experiment; we find from A and C, that the sun's rays have the power of eliminating gas from its solutions; from B we learn that the absence of the chemical rays does not affect the *apparent* result, but that if the calorific rays are obstructed, it ceases to go on.

39. A variety of experiments having thus convinced me, that the mere evolution of gas, is neither due to the rays of light, nor to the chemical rays, I have attempted to produce a like effect with the calorific rays, emitted from a common fire; rays, in which the light was altogether disproportioned to the heat, and the chemical power totally wanting. The arrangement is as follows; in the focus of a concave speculum of brass eighteen inches in diameter, I placed one of the glass globes of the preceding section, so that it might receive the rays emitted from a common wood fire, converged on it by the mirror. The fire was burning without flame, being what is technically called a dead fire, and the distance of the mirror eight feet. In a few moments, gas was copiously liberated, more copiously than if it had even been exposed to the solar ray. In Fig. 20 this arrangement is depicted, *a* is the concave mirror, *b* the glass mattrass, filled with spring water and containing a bunch of pine leaves, *c* a cup of mercury into which its neck might dip.

40. I shall have occasion to remark hereafter, that when a beam of light falls upon any surface in contact with a medium, it causes that surface to exert an apparent pressure on the medium, capable at times of producing singular effects; it is therefore probable, that to this action we are to attribute the evolution of gas by vegetable leaves, spun glass, raw silk, &c. The percolation of liquids and gases, through tissues in obedience to the laws of capillary attraction, should also, on these principles, be controlled by the action of a solar beam. If we arrange two champagne glasses, with their footstalks cut off, and capped with a thin lamina of Indian rubber, their various apertures dipping into cups of water, so that they may be in all

respects as like each other as possible, and fill them with protoxide of nitrogen, we shall find, that one of them exposed to the sunbeam, will throw off its gas much quicker than the other, shut up in the dark. Or, if one of them be exposed to an atmosphere, much warmer than the other, the liquid confining the gas in it, rises far more rapidly. It has been remarked to me, by some chemist, that the experiment of which I gave an account, in the Journal of the Franklin Institute, Vol. XVII, p. 177, of the passage of hydrogen gas through a thin film, without pores of sensible size, is not uniformly attended with success. In examining the causes of failure, I have been able to trace them, entirely to this source; at a certain temperature, the effect is scarcely perceptible, but as the thermometer rises, it becomes more and more marked. The same observations may be made of ammoniacal vapour. There are temperatures at which these permeations are imperceptible, but at 75° Fah. they take place with great rapidity.

41. Rays of radiant heat, whether of the Sun or of terrestrial fire, pressing on the surface of an obstacle, cause it to exert an increased action, resembling a force of attraction or pressure, on any medium with which it may be in contact. A few fibres of unspun silk, being immersed in water containing the elements of atmospheric air in solution, and exposed to the sunshine, became speedily covered with bubbles of gas. The exact chemical constitution of these bubbles, is determined by a variety of circumstances, the velocity of evolution, by the solvent action of the water, which is greater for one gas than another, and by the presence or absence of the chemical rays. I shall here be excused for remarking a circumstance which appears to me indicative of a proneness even in capillary compounds, to exhibit tendencies of combination by multipule volumes. Atmospheric air contains oxygen and nitrogen, in the proportion of 1 to 4; the gas expelled from spring water, contains the same element in the proportion of 1 to 2; and the gas given off by pine leaves from water, holding carbonic acid in solution, contains the same elements in the proportion of 2 to 1.

42. The chemical rays emitted from the Sun, are not, therefore, the cause of the evolution of gas from liquids by fibres, or by vegetable leaves, for it takes place in their absence; the blue, the indigo, and the violet rays, have nothing to do with it for the same reason; and the green, yellow, orange, and red, are not the cause of it, for though they are present, it refuses to go on. To the calorific ray, we are therefore to impute it; it happens, not by the action of any kind of light, acting as a mere stimulus on plants, for when the light is nearly absent, it goes on with undiminished energy.

(TO BE CONTINUED IN THE NEXT.)

Bibliographical Notice.

An Elementary Treatise on Astronomy, in two parts,—the first containing a clear and compendious view of the theory—the second a number of practical problems; to which are added Solar, Lunar and other Astronomical tables. By JOHN GUMMERE, A. M. &c., *second edition, enlarged and improved. Kimber & Sharpless*, 1837.

That a second edition of this valuable treatise should be called for, even after the lapse of several years, is an evidence of an increasing taste for the exact sciences among the schools of this country. That the mere outlines of Astronomy, as exhibited in such little books as those of Treeby,

Wilkins, Wilbur, Squire, Ryan, and some others, are very commonly taught, even in Female Boarding Schools, is very well known; but prior to the appearance of Gummere's Astronomy there was no work known in this country, and indeed we may say, of moderate size, in the English language, well adapted to initiate the student in the theoretical doctrines of this most elevated science, and to confirm his knowledge and his taste by placing before him the means, and making it a part of his duty, to go over the demonstrations, to enter the calculations, and to form projections of some of the more interesting phenomena. Without this, it is impossible fully to comprehend and justly to appreciate the labours of those great minds from whose discoveries the world is deriving such a vast accession of intellectual power. Popular illustrations are better than nothing. They may serve to awaken curiosity, and possibly stimulate a few to further investigation and deeper study; but every teacher who is imbued with a real love of mathematics, must have felt, like the estimable author of this work, the superficiality of all the common school books, and the necessity of a treatise which should better answer the designs of thorough instruction. Gummere's treatise is adopted in some of the colleges, and is now, we are pleased to learn, a text book in the highest mathematical school in this country, the military academy at West Point. This second edition, the author informs us, "has received considerable additions in both parts. A general analytical investigation of eclipses of the sun, occultations, and transits has been introduced, and the formulæ obtained are applied in practical problems for calculating these phenomena. The table of the sun's epochs, commencing with the year 1836, has been improved by the application of Bessel's corrections. The Tables of Epochs both for the Sun and Moon have been extended, and tables for the planet Mercury abridged from Lindenau's tables and adapted to the meridian of Greenwich, have been introduced, serving to illustrate the method of calculating the place of a planet; and they are sufficiently accurate for determining nearly the times of a transit of this planet over the Sun's disc. Several other useful tables have been added.

Whoever wishes to teach the elements of *practical* Astronomy without the trouble and expense of importing books of tables, will find this work almost indispensable. It must have cost the author much time and labour, and an ingenious analytical method of his own, for calculating eclipses, is not elsewhere to be met with, except perhaps a paper in the transactions of the American Philosophical Society, furnished by himself.

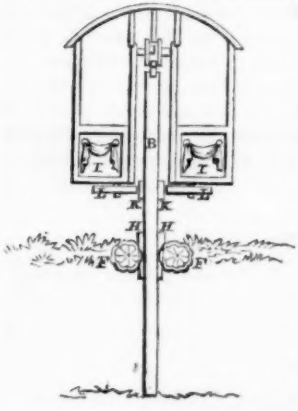
Mechanics' Register.

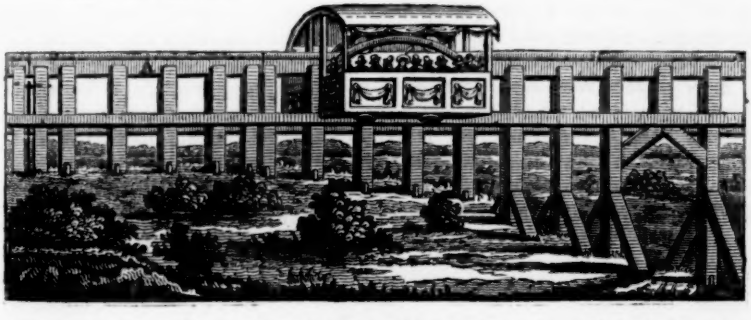
Specification of a patent granted to URI EMMONS, *of Freehold, Monmouth County, New Jersey, for a single Rail, Rail-Road.*

To all whom it may concern: be it known, that I, Uri Emmons, of Freehold, in the county of Monmouth, and State of New Jersey, have invented certain improvements in the manner of constructing rail-roads of that kind, in which the carriage way consists of a single rail, elevated upon posts; and I do hereby declare that the following is a full and exact description thereof.

The general construction of the single rail which I use is the same with that for which letters patent were obtained by a certain Henry R. Palmer, in England, in the year 1821. This single rail is elevated upon posts

set in the ground, the rail being secured on the tops of the posts, and covered with an iron plate on its upper side. The strength of the rail must be such as to sustain the load which is to bear upon it, and this will be governed by the distance of the posts apart which support it. The accompanying perspective drawing represents the rail, supported upon posts and covered by the iron rail plate. The posts may sometimes be mortised into a ground sill, but as ground is generally uneven, and as this mode of constructing rail roads is intended to obviate the necessity, in the greater number of cases, of excavating and embanking, by giving the posts the proper length to reach the level of the rail, a horizontal ground sill can rarely be used; and it is desirable to be able to fix these posts firmly at their lower ends, by means which shall be adapted to uneven ground, be efficient without being costly, and be well calculated to keep the posts in a vertical position, and allow of their adjustment when necessary. To effect this I take trunks of trees, from which I hew off a portion of one side, so that they will lie along against the posts, as shown in the transverse view at F. These logs may be buried partially, or wholly, in the ground, and they must be bound together by bolts, or cross-ties, in any convenient way. Between the vertical posts and the above named logs I insert wedges H, H, by the driving of which the posts may be, at any time, firmly fixed in a vertical position, and regulated as may be desired. When the vertical posts are of considerable length, lateral braces must be used, and these may rise from cross sills which rest upon the trees, or logs, and which may serve at the same time as cross ties to these logs.





Where it has been proposed to use a single rail, such as I have described, it has also been intended to construct a car, or carriage consisting of two parts, to be suspended from the rail, one part on each side thereof, with wheels between them, near their tops, to bear upon the rail, in a manner analogous to that shown in the transverse view, where I, I, are the two parts of the car, or carriage, and J, one of the running wheels. The main improvement which I have made in this part consists in the employment of guide rails K K, which run along on each side of the posts, to which they are firmly affixed. These may ordinarily be placed about three feet

below the top of the rail, and opposite to them; upon each section of the car, or carriage, I place friction rollers, or wheels L, L, which generally run free of the guide rails, but come into contact therewith when, from any cause, the carriage tends more towards the rail on one side than on the other. Other modes of fixing guide rails, and friction rollers, may be devised which will be substantially the same in operation as that above described; as, for example, there may be an edged rail running along under one section of the car or carriage, supported by arms from the vertical posts, and two friction rollers attached to the under side of the section of the car, or carriage, may bear, one on each side of such edge rail, or plank. Such a plan, however, would not, in my opinion, be equally good with that first described, and I give it therefore, merely, as an exemplification of one variation of my plan. The turn-outs which I intend to use resemble those described by the before-named Palmer, and I do not, therefore, claim any thing new in this part of the structure. But what I do claim as of my invention is the manner herein described of fixing and regulating the vertical posts by means of logs placed in the ground, along their lower ends, with wedges to be driven in between the logs and the posts. I also claim the employment of guide rails and friction wheels in a single rail rail-road, placed in the manner, and for the purpose described, whether the same be effected precisely in the way herein set forth, or in any other analogous thereto, and producing a like result. URI EMMONS.

Preservation of Zoological Specimens.

I have often noticed with regret, both in some public and private museums, in this country, that the damp was making fearful inroads among the zoological specimens; and, as I learned, while in France, some time since, a most simple and efficacious remedy for that evil, I beg to submit it to you for the benefit of your readers and the public.

A glazed flower-pan, of the size of a dessert plate, placed in the cases, at intervals of 8 or 10 feet, and filled with quicklime, will rapidly imbibe all damps, and will only require renewing when it is found that the lime is completely saturated.

As a preventive to moth in museums, I have seen used, and have used myself with great effect, the huile de pétrole, put into glass vessels like shallow finger-glasses; and four or five in a case of 20 feet long will produce so powerful an effluvium, that it is necessary to have as many watch-glasses, with small portions of musk in them, to make it bearable. But this, in good air-tight cases, is of little consequence.—*Kent, Dover, Jan.* 5, 1837.

Loudon's Mag. Nat. History.

New Bee Hive.

An inhabitant of Connecticut, Mr. Judd, has invented a contrivance, by means of which bees are made to build their cells, and deposit their honey in the chamber of a dwelling-house, in neat little drawers, from which it may be taken fresh by the owner, without killing the insect. *The New York Gazette* describes it as follows:—"The hive has the appearance of, and is in part, a mahogany bureau or sideboard, with drawers above and a closet below, with glass doors. The case or bureau is designed to be placed in a chamber of the house, or any other suitable building, and connected with the open air or outside of the house by a tube passing through the wall.

The bees work and deposit their honey in drawers. When these, or any of them, are full, or it is desired to obtain honey, one or more of them may be taken out, the bees allowed to escape into the other part of the hive, and the honey taken away." The glass doors allow the working of the bees to be observed; and it is added that the spaciousness, cleanliness, and the even temperature of the habitations provided for them in this manner, render them the more industrious. Farm. Mag.

Caoutchouc Hose.

An interesting experiment took place on board the powerful floating engine belonging to the London Assurance Corporation, the other day, in the presence of the directors, to ascertain the strength of a newly invented hose made of caoutchouc, or India rubber. A length of leather hose and one of India rubber were attached to the engine, each furnished with a branch tightly corked. On working the engine for a short time the leather hose, unable any longer to resist the accumulated pressure, burst in the solid part of the leather, while the India rubber hose remained firm and uninjured; and the engine itself became disabled by the breaking of one of its cranks, without producing any effect upon the elastic material of which the new hose is constructed. Mining Journal.

Effects of Sea-water on Iron.

Iron, after remaining a long time submerged in the sea, is converted into plumbago. As an evidence of this change, M. Eudes Deslongchamps has lately presented to the Linnæan Society of Normandy some cannon balls taken from the bottom, off Cape le Hogue, which were sunk with the ships under Admiral Tourville, in 1692. They do not at first sight appear to have undergone any change; but when examined, are found to have lost two-thirds of their weight, and may be scraped or cut with a knife, like black lead. They contain no remains of their original ferruginous qualities, and have not the least effect upon the loadstone or magnetic needle. Ibid.

Twisted Metallic Wire.

An experiment took place in the Chain Cable Proving-house, Woolwich Dock-yard, before Rear-Admiral Sir W. Parker, upon a specimen of rope made out of twisted metallic wire; it snapped, however, upon the first application of tension. Ibid.

Variation of the Magnetic Needle, at London, Dec., 1836.

If inquiry be made for the accurate amount of the present variation of the magnetic needle at London, it is remarkable how difficult it is to obtain anything like a satisfactory answer. A valuable correspondent has enabled us to make the following communication.

"On December the 14th last, I found, by equal altitudes, with a good instrument, that the variation was 23° 37′ 30″ West.

"*Fleet street, Feb*, 25, 1837." Mag. Pop. Sci.

LUNAR OCCULTATIONS FOR PHILADELPHIA. JULY 1837.

Angles reckoned to the right or westward round the circle, as seen in an inverting telescope. For direct vision add 180°

Day.	H'r.	Min.	Phase	Star's name.	Mag.	from Moon's North point.	from Moon's Vertex.
13	10	23	Im.	f^2 Scorpii.	6,	61	86
13	11	38	Em.			267	304
15	13	58	Im.	(359) Sagittarii,	5,	143	182
15	14	42	Em.			230	274
19	16	3	Im.	f Aquarii,	6,	98	119
19	17	2	Em.			333	365
20	11	22	Im.	Ψ'' Aquarii,	5,	123	80
20	12	29	Em.			298	263
29	14	32	Im.	47 Geminorum,	6,	113	70
29	15	21	Em.			254	206

Meteorological Observations for March, 1837.

Moon.	Days.	Thermometer. Sunrise	Thermometer. 2 P.M.	Barometer. Sunrise	Barometer. 2 P.M.	Wind. Direction.	Wind. Force.	Water fallen in rain.	State of the weather, and Remarks.
				Inches.	Inches.			Inches.	
⊗	1	29°	39°	29.90	30.05	W.	Moderate.	.8	Cloudy—snow.
	2	15	22	30.30	29.95	NE.	do.		Cloudy—lightly cloudy.
	3	18	36	15	15	NE.	do.	.15	Snow—clear.
	4	3	31	95	95	W.NE.	do.		Clear—clear.
	5	20	33	20	20	NE.	do.		Lightly cloudy—clear.
	6	19	43	25	25	SE.	do.		Clear—clear.
	7	32	50	10	5	E.	do.		Partially cloudy—do. do.
	8	36	51	00	00	E.	do.	.8	Drizzle—rain.
	9	47	44	29.90	29.90	N.	do.		Fog—drizzle.
	10	33	45	30.15	30.15	NW.	do.		Partially cloudy—clear.
	11	32	43	29.30	30.30	N.	do.		Clear—do.
	12	30	48	30.30	16	E.	do.		Lightly cloudy—do. do.
	13	40	57	29.84	29.70	SW.	do.	.30	Cloudy—rain.
☾	14	43	46	60	85	W.	Brisk.		Flying clouds—do do.
	15	27	36	30.10	30.10	N.NW.	Moderate.		Cloudy—clear.
	16	24	43	25	27	NE.W.	do.		Clear—do.
	17	30	53	27	26	W.	do.		Cloudy—rain.
	18	39	46	29.50	29.50	S.SW.	Brisk.	.8	Clear—flying clouds.
	19	39	35	60	70	W.	do.		Cloudy—partially cloudy.
	20	32	38	30.00	30.10	SE.	Moderate.		Cloudy—rain.
	21	30	32	29.85	29.90	SE.	do.	1.80	Rain—do.
	22	50	44	60	60	SE.	do.		Cloudy—snow—cloudy.
	23	33	41	70	63	NW.	do.		Clear—cloudy.
	24	35	53	30.05	30.05	W.	do.		Clear—do.
	25	34	50	00	00	W.	do.		Cloudy—clear.
	26	43	50	29.90	29.60	N	do.		Clear—cloudy.
	27	46	56	80	80	E.	do.		Rain—clear
	28	40	60	64	64	SE.SW.	do.	.14	Fog—hazy—thunder showers.
○	29	34	46	61	74	NW.	do.	.24	Flying clouds—do.
	30	36	40	30.01	30.01	W.	do.		Clear—cloudy.
	31	34	43	29.90	29.70	SE.	do.	.70	Cloudy—do.—rain in night.
	Mean	11 61	13 87	29.95	29.91			3.77	

Thermometer.
Maximum height during the month 69, on 28th.
Minimum do. 3, on 4th.
Mean do. 37.74.

Barometer.
30.30 on 2nd and 11th.
29.00 on 26th.
29.93.

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